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CALIFORNIA SEWAGE WORKS JOURNAL

Official Publication of the California Sewage Works Association

Vol. VI • 1933 • No. 1

Minutes of the
Sixth Annual Convention at Santa Cruz

Multi-Stage Digestion of Sludge

Ammonia Removal from Sewage

Methods for Determining Chlorine Demand

Utilization of Sewage Gas

Symposium on Operators' Experiences

The Recovery Act in Relation to A. B. 980

Gases in Sewer Manholes
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The California Sewage Works Association is not responsible, as a body, for the supposed facts and opinions advanced in any of the papers, discussions, or articles published in this Journal. Discussion of all papers is invited.

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1933 ANNUAL CONVENTION

Santa Cruz

September 18-19, 1933

Headquarters, Hotel Palomar

Program

MONDAY, SEPTEMBER 18, 1933

8:00 a. m.—Meet at Hotel Palomar, Santa Cruz.
8:15 a. m.—Trip to Big Basin, California Redwood Park.
9:15 a. m.—Inspect Big Basin sewage disposal works.
10:00 a. m.—Return to Santa Cruz.
11:00 a. m.—Visit Santa Cruz screening plant.
12:00 m. —Fish luncheon at municipal wharf, Santa Cruz.
1:00 p. m.—Inspect ocean outfalls and witness uranine dye test.
2-5 p. m. —Technical session with papers as follows:
(1) 'Performance of the Santa Cruz Ocean Outfall', by Roy Fowler.
(2) 'Recent Experiences with Multi-Stage Digestion of Sludge', by A. M. Rawn.
(3) 'Removal of Ammonia from Sewage by Zeolite', by M. J. Conover and O. C. Ralston.
7:00 p. m.—Informal dinner; annual meeting of governing board.

TUESDAY, SEPTEMBER 19, 1933

9:00 a. m.—Business meeting, with election of officers.
10:00 a. m.—Technical session with papers and symposium, including:
(4) 'Comparison of Methods for Determination of Chlorine Demand', by A. C. Beyer.
(5) 'Troubles with Utilization of Sewage Gas', by Alva J. Smith.
(6) 'Symposium on Operating Experiences', by Russell C. White, S. M. Bennett, W. A. Allen, C. Tennant, A. E. Gilkey, and others.
12:00 m. —Luncheon and round-table discussion.
2-5 p. m. —Joint session with Engineers and Street Superintendents' Section, League of California Municipalities.
(7) 'The National Recovery Act and its Relation to the California Sewer Revenue Bond Act', by C. C. Kennedy.
(8) 'Use of Assembly Bill No. 980 with Reference to Sewer Service', by W. T. Knowlton.
(9) 'Signs of Sewage-Mindedness in the San Francisco Bay Region', by L. C. Macabee.

SIXTH ANNUAL C.S.W.A. CONVENTION AT SANTA CRUZ, SEPTEMBER 18-19, 1933

By E. A. REINKE*

Morning Session, September 18

A group of 70 C.S.W.A. members and guests assembled at the Palomar hotel, Santa Cruz, at 8 a.m. and were escorted in automobile caravan to the California Redwood Park.

Warden Gray and chief deputy Park greeted the party and the latter conducted a short trip through the big trees to the septic tank and cesspools which serve most of the area. Individual cesspools were also shown to the party. The cesspools are not satisfactory because of tight soil. In the main system, the septic tank effluent, after flowing through several long narrow cesspools, is run through a trench filled with sand and charcoal, and finally discharged under water to Sempervirens creek.

The caravan returned to Santa Cruz and visited the sewage screening plant. City Engineer Roy Fowler and commissioner Bibbin were on hand to explain operation of the plant, consisting of fine screens and sewage pumps.

A fish luncheon was served at the Ideal restaurant on the municipal wharf (attendance 70).

The party next assembled at the shore end of the ocean outfalls. Two outfalls originally 2000 ft. long were layed, but one is broken at 1100 ft. Uranine dye was added through a manhole; it appeared in the ocean at the end of the shorter line after passing through 1100 ft. of 16-in. o.d. pipe in about 17 min. Most of the party left, but the dye was observed at the end of the longer outfall about 45 minutes after its addition. A broken section of pipe from the outfall was brought on a truck to show the character of the break.

Afternoon Session, September 18

The meeting was called to order by president Jacobson. City Engineer Roy Fowler, of Santa Cruz, presented a paper on 'Performance of Santa Cruz Outfalls'. Several maps, charts, and photographs were used in explaining the experiences with breaks, repairs, and anchoring. A number of questions were asked, particularly with reference to anchorage and future repairs to the line. In the discussion the point was brought out that several private sewers discharge to the ocean at or near shore, and bacterial sampling would not necessarily tell the true story of outfall performance. Discussion

* Secretary-treasurer, California Sewage Works Association; senior sanitary engineer, State Department of Public Health, Berkeley.

was led by A. M. Rawn, W. T. Knowlton, and D. E. Perry.

The second paper presented was entitled 'Recent Experiences with Multiple Sludge Digestion' by A. M. Rawn. Experiences with operation of the Los Angeles County Sanitation Districts' plant were described. This paper was discussed by E. A. Reinke, R. F. Goudey, T. R. Haseltine, R. C. Pomeroy, A. M. Kivari, D. E. Perry, C. G. Hyde, W. A. Allen, R. C. White, and A. P. Banta.

The final paper for the session was presented by M. J. Conover and entitled 'Removal of Ammonia from Sewage by Zeolite'. This paper was discussed by R. F. Goudey, B. Benas, R. C. Pomeroy, T. R. Haseltine, R. C. White, and E. A. Reinke.

An informal, speech-less dinner was held in one of the private dining rooms of the Palomar hotel. Fifty-one members were in attendance with director Alexander Bell as toastmaster.

After the dinner president Jacobson called the annual meeting of the governing board.

Morning Session, September 19

The business meeting was called to order by president Jacobson.

Alexander Bell, reporting for the membership committee, stated that the membership would be given in the secretary's report.

W .T. Knowlton and C. C. Kennedy reported for the legislative committee. Necessity or desirability of court decisions on the sewer revenue bond bill was the chief point discussed. A. G. Darwin asked if any other city than Oxnard was proposing to use A. B. 980 (the above bill). None was known to members present.

A. G. Darwin, chairman, reported for the publicity committee that 150 letters had been sent to newspapers throughout the state stressing the relationship of sewerage improvements to the N.R.A. program, but even that appeal had not resulted in publicity for the meeting or the association.

A. M. Kivari and A. C. Beyer reported for the committee on licensing operators. Beyer reported that Montana and Michigan were working on licensing laws. R. F. Goudey, president, California Section, A.W.W.A., was asked for his ideas on a joint committee of the water works and sewage works associations. At his suggestion the secretary was instructed to write a letter to the secretary of the California Section, A.W.W.A., requesting the appointment of a committee on licensing to work jointly with the C.S.W.A. committee.

Fred Bowlus, chairman, reported for the committee on safety regulations, stating that several meetings had been held, but the time is not ripe for the State Industrial Accident Commission to draw up general regulations.

C. G. Hyde, chairman, reported for the committee on award. The award will be made as usual at the spring conference. On motion from the floor, this committee was given a rising vote of thanks.

F. A. Batty, chairman of the auditing committee, reported the

records of the secretary-treasurer to be checked, showing a cash balance of $191.70.

President Jacobson asked for a rising vote of thanks to all committees for their work during the past year. This was done.

The secretary-treasurer's report showed a paid-up membership of 217, a net loss of 2. The cash balance was $84.37 less than last year due to a heavy deficit in publication of the Journal. The governing board appointed a committee of manufacturers to provide for financing of the Journal, consisting of Alexander Bell and A. T. Wintersgill. The board also decided to publish two journals a year, within 60 days following the meetings.

The nominating committee, consisting of Bowlus, Hyde, and Wyman, presented the following names:

President	D. C. McMillan
1st Vice-President	T. R. Haseltine
2nd Vice-President	A. M. Rawn (named by Hyde and Wyman)
Secretary-Treasurer	E. A. Reinke
Director	A. G. Darwin
Board of Control	C. G. Gillespie

The report was accepted and the above named members unanimously elected.

A paper entitled 'Comparison of Methods for Determination of Chlorine Demand of Sewage' was read by A. C. Beyer, and discussed by A. P. Banta, R. F. Goudey, F. D. Bowlus, B. Benas, and C. G. Hyde.

The secretary read A. J. Smith's paper, 'Troubles with Utilization of Sludge Gas'. Lively discussion followed, participants including C. C. Kennedy, R. F. Goudey, T. R. Haseltine, R. C. Pomeroy, J. J. Jessup, C. G. Gillespie, Carl Tennant, and E. A. Reinke.

The discussion was continued in an Operators' Symposium. W. A. Allen, S. M. Bennett, C. Tennant, R. C. White, A. C. Beyer, T. R. Haseltine, R. F. Goudey, and A. E. Gilkey discussed their various experiences. Gilkey told of unusual experiences with fungus growths (probably sphaerotilus) at Roseville. C. C. Kennedy related similar experiences at Dunsmuir and at Sparks, Nevada. C. G. Hyde explained that these growths were usually found in places having soft cold waters, when infiltration to sewers is very high.

An informal luncheon with president-elect McMillan as chairman was followed by a discussion on publicity. Many viewpoints were brought out by members, some suggesting the necessity of doing things in a spectacular way. H. F. Gray, T. R. Haseltine, Carl Hoskinson, C. C. Kennedy, W. T. Knowlton, F. Hammerly, D. C. McMillan, A. M. Rawn, R. R. Ribal, A. Bell, J. J. Jessup, C. G. Gillespie, H. R. Crane, A. G. Darwin, and several others participated in the discussion.

Afternoon Session, September 19

The annual joint meeting with the Engineers and Street Superintendents' Section, League of California Municipalities, was opened by Lyle Payton, who welcomed our association and turned the meeting over to president Jacobsen.

The first paper was by C. C. Kennedy, on 'The National Recovery Act and Its Relation to the California Sewer Revenue Bond Act'.

Discussion was by B. D. Phelps, Merrill Butler, E. L. Grant, D. E. Perry, W. T. Knowlton, A. T. Wintersgill (read Robert Linton paper), J. J. Jessup, Reinke, G. S. Backus, H. I. Stites, Austin Burt, C. C. Kennedy, Carl Hoskinson.

L. C. Macabee presented a paper on 'Signs of Sewage-mindedness in the San Francisco Bay Region', which was discussed by J. F. Byxbee and C. G. Gillespie. D. C. McMillan introduced Geo. C. Powers, formerly county engineer at Ventura and city engineer, now city councilman; also councilman Mercer.

PERFORMANCE OF THE SANTA CRUZ SEWER OUTFALL

By ROY FOWLER*

In calculating the disposal of screened sewage from the Santa Cruz outfall by disposal into the Pacific ocean it was assumed that: (a) organic matter in the sewage is completely oxidized; (b) the sewage is domestic; (c) the flow is 3 m.g.d.; (d) 570 c.c. of oxygen is required per gallon of sewage; (e) wind movement averaging 10 mi. per hr. during June to September, with resulting wave action, will cause each square foot of ocean surface to absorb at least 300 c.c. of oxygen per 24 hr.; (f) the fresh sea water available for dilution will always be completely saturated with oxygen at highest temperature of at least 160 c.c. of oxygen per cu. ft.; (g) each inhabitant contributes an average of 100 g.p.d. of sewage.

Mean tidal range at the outfall is 4.6 ft., representing the average volume of fresh unpolluted sea water passing the outfall 1.94 times daily, average duration of two tidal cycles being 24 hr. 48 min., or 12.4 hr. per cycle. The use of vane and bottle floats and tidal height gave a means for determining the volume of the tidal prism required for sewage dilution. It was found that the outfall could be 20 ft. deep, but due to the shape of the ocean floor the line was laid 2000 ft. offshore where the depth is 40 to 50 ft.

The contract to construct new sewage disposal works was awarded in January 1927 on a bid price of $407,783 ($92,500 representing out-

* City Engineer, Santa Cruz, California.

falls) and completed in May 1928. The outfall begins at a pumping plant at Neary's lagoon. Here sewage is concentrated in a sump, passed through fine rotary screens, and pumped into a concrete pipe laid in a 4400-ft. tunnel, discharging to a surge chamber in the face of a cliff on the ocean beach. From this point two outfall pipes, each 2000 ft. long, extend into the ocean. The pipes were laid close together at the shore ends, tapering to 200 ft. apart at the discharge points. Provision for two more outfalls was made in the surge chamber. The pipes are 16-in. o.d. hand-puddled wrought iron, with ½-in. shell for the first 500 ft. and ⅜-in. thereafter. From 100 to 500 ft. offshore the pipes are protected by a 20-in. o.d. galvanized welded sheathing 3/16-in. thick. The annular ring between sheathing and pipe is filled with cement grout in which is embedded a continuous band of 9-ga., 1½-in. mesh galvanized wire.

Both outfall lines were assembled on shore, launched, and sunk. Anchors, consisting of concrete mixed dry in sacks, with the sacks slashed to insure bond, were then piled on and around the pipe by divers. For the first 450 ft. from shore the anchorage was a 1-in. steel chain embedded in sand and rock and secured to the pipe at 50-ft. intervals. Late in 1928 inspection by a diver showed all but one anchor to be in good order.

In early 1930 washing of sand on the beach exposed the pipe, and a section of the sheathed line showed a parted joint when the pumps were started. That winter there had been a severe storm at sea and an underwater survey disclosed that the pipes were unsupported at many points. The east line was broken 1100 ft. from shore and the west line was without anchors 800 ft. from shore; furthermore, the east line had been curved into a semi-circle. The ocean floor beyond a point 800 ft. from shore was a hard, smooth shale and the current was so strong that the diver could not keep his footing.

It was decided to repair the line by placing concrete supports at depressions and installing a new type of anchor. Blocks of tremie concrete 16 by 4 by 4 ft. were placed around the pipe in a trench excavated in the shale after blowing away the sand with compressed air. At the broken point in the line the pipe was unsupported for 60 ft. and it was necessary to install a Victaulic joint and build up supports to remove the sag from the line. The next year the curved section of the east line broke in a heavy storm, but has not since been repaired. Each year a uranine dye test is run to check pipe movements and further leaks. Currents at the point of break are strong and discharge sewage into a deep channel flowing toward Monterey bay, so that even with the outfall in its present condition the disposal is satisfactory.

Repairs cost $14,750 and saved all of the west line and 1100 ft. of the east line.

RECENT EXPERIENCES WITH MULTI-STAGE DIGESTION OF SLUDGE AT THE JOINT DISPOSAL PLANT OF THE LOS ANGELES COUNTY SANITATION DISTRICTS

By A. M. RAWN*

Two years ago last July the Los Angeles County Sanitation Districts placed in operation at their joint disposal plant, near Harbor City, two batteries of multiple-stage digestion tanks. The tanks were designed upon basic data obtained from experimental work conducted by the districts at their disposal plant and incorporated certain principles of operation and control not otherwise in use for this purpose.

The principal departure from sludge digestion design and operation elsewhere is the advantage taken of a feature described as the gravimetric segregation of sewage solids in bulk or the natural tendency of sludge en masse to stratify according to the specific gravities of its various particles.

Quoting from an article descriptive of these tanks, published in 'Civil Engineering' in August, 1931, the gravimetric principle as incorporated in the design of the tanks under discussion is defined as follows:

> A characteristic of sewage sludge is that, when digested, it has a higher specific gravity, on the average, than when undigested. It is also well known that a high percentage of sewage solids is inorganic and that upon these the digestion process has no important effect. These inorganic solids are also, as a rule, heavier than the run of organic solids. Sludge digestion is essentially the reduction of organic material by liquefaction, gasification, and change, to a more stable composition. Thus the digested sludge is a combination of the original inorganic, the metamorphosed organic, and such other organic solids as the reduction process will not influence. The time of detention, other factors being equal, has a major influence upon the reduction of the organic solids, and if this influence can be brought to bear upon the selected organic materials, with the inorganic materials separated out and passed ahead with the ripened sludge, it may be seen that a tank or group of tanks of given capacity may be thus used to digest a larger gross quantity of solids than when the entire bulk is retained in the tanks until completely digested.

Two batteries of stage digestion tanks have been constructed. They are identical in all of their principle features, each battery being rectangular in plan, 56 ft. wide and 150 ft. long, with an effective depth of about 15 ft. Three transverse walls divide each battery into four rectangular tanks, each 56 ft. wide and 37.5 ft. long. As may be noted from the longitudinal section shown, the tanks are offset vertically, the difference in elevation of the sludge surfaces in each successive tank being about 4 ft. The slope of the bottom of the battery is uniformly 1:12, and each tank in the battery of four is equipped with a hopper at its lower end, directly against the transverse wall dividing it from the next tank in succession. All tanks

* Assistant Chief Engineer, Los Angeles County Sanitation Districts.

are topped with solid concrete covers. Each tank is equipped with two longitudinal baffle walls, dividing it into three bays of equal capacity. The walls extend from within a foot of the tank bottom to the tank cover and are pierced with 6-in. apertures near the cover to permit the release of sludge gas to a common outlet. Thus each tank becomes in reality three nearly separate bays and it is necessary for sludge and raw solids, introduced into the two outer bays of any tank, to reach the bottom of aggregate mass in these bays before it can pass into the central bay.

The process of operation is as follows. Raw primary-clarifier and activated-sludge solids plus about 20% by volume of digested sludge are introduced into the two outer bays of Tank No. 1 in either of the two batteries and the temperature of the mass raised to approximately 85°F. Gravimetric segregation commences immediately because, to reach the central bay of Tank No. 1, solids must sink to the bottom of the mass in the outer bays and pass under the baffle wall. To pass ahead from the central bay of Tank No. 1 to the two outer bays of Tank No. 2, the solids must stay near the bottom and accumulate in the tanks and hopper. Tanks No. 2, 3, and 4 of each battery are identical in size and all other characteristics, to those in Tank No. 1, and thus the selective process continues throughout the entire time of travel from the entrance of the raw sludge and seed into Tank No. 1 until its exit from the central bay of Tank No. 4 into the sludge-storage well. Thus any material must undergo the process of selection by weight eight times in order to leave the tanks and if the principle of gravimetric segregation holds true, the solids which are heavier, and correspondingly more inert, will travel through the tanks at a faster rate than those which are lighter and more volatile.

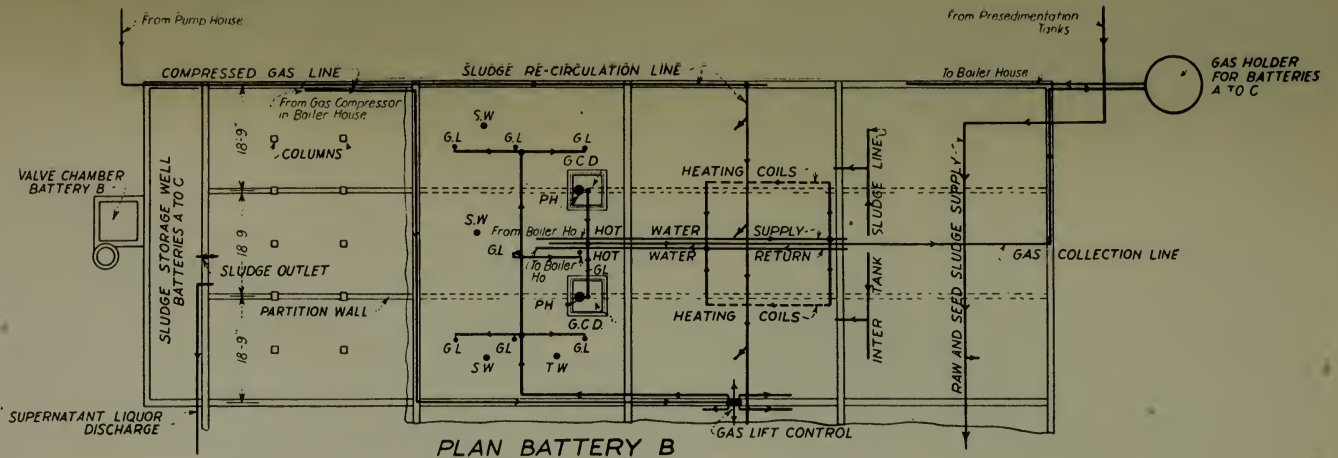
During the period April 27 to June 12, 1933, an analysis was made of the tanks' operation with a view to determining the quantity and quality of sludge going to and drawn from the tanks, the detention period in the tanks, gas production, volatile solids (including ether soluble) reduction, and the nitrogen balance in the raw sludge, supernatant liquid, and digested sludge. Some further incidental factors were determined.

TABLE I—AVERAGE DAILY SLUDGE PUMPED TO DIGESTORS

Total of Raw & Activated

Interval Number	Interval From	Interval To	Days	Sludge lb. per day
3	May 9	May 16	7	997,000
4	May 16	May 23	7	996,000
5	May 23	May 30	7	1,163,000
6	May 30	June 5	6	1,061,000
7	June 5	June 12	7	1,101,000

Period Average—1,064,000 lb. daily; 127,000 gal. daily.



Multi-Stage Sludge Digestion Tanks, L. A. County Sanitation Districts.

(For General Layout and Cross-Section, see p. 20)

Measurements of the volume of sludge removed from the digestion tanks were made during the period of observation. From these data, weighted by the gas production and supernatant liquid withdrawn, the amount of raw sludge pumped to the digestors was calculated and the test period divided into seven intervals of seven days each, with results for each period averaged. This discussion will refer largely to periods 3 to 7 when supernatant liquor was being withdrawn from Tank No. 3.

The tanks were originally designed for the digestion of primary-clarifier sludge only and it is expected they eventually will be used solely for such purpose, but at the present time, because the districts are operating a temporary activated sludge plant in place of a plain subsidence plant (the future installation), both primary-clarifier sludge and activated-sludge are being digested in the tanks. Therefore, these operation data refer to the digestion of a mixture of the two, generally conceded to be a more difficult task than the digestion of primary-clarifier sludge alone. From an inspection of Table I, it may be seen that the sludge in pounds per day pumped to the digestors varied from 996,000 to 1,163,000 and averaged 1,064,000, or 127,000 gal. The average daily sewage flow for the period of observation was 14.3 m.g.

TABLE II—AVERAGE SOLIDS CONTENT OF DIGESTED SLUDGE

	% Moisture	% Total Solids	% Volatile
Battery A	96.316	3.684	53.4
Battery B	96.145	3.855	52.4
Battery A & B	96.23	3.770	52.9

From May 11 to June 13 samples of digested sludge were analyzed. In all, 13 samples were taken from each battery, a total of 26, each composited of seven sub-samples extracted during periods of pumping sludge from the battery to the drying beds. Thus the results taken during this 30-day period are the average of 182 separate specimens. Due allowance was made for solids content of supernatant liquid withdrawn and for the amount of ash entering the digestion tanks with seed sludge, and determinations made daily to fix these values which were taken into consideration in setting up values showing solids in the digested sludge. From this calculation, it is disclosed that the average solids content of the digested material issuing from the tanks is 3.77%, of which solids 52.9% are volatile.

Knowing the volume of digested sludge withdrawn from the tanks, the quantity of seed sludge pumped into Tank No. 1, together with the ash analysis of supernatant liquid withdrawn during the observation period, and the ash content of the digested sludge withdrawn, it is possible to calculate the net amount of ash withdrawn from the digestors resulting solely from the input of raw solids. This calculation is made upon the generally conceded assumption that the ash

TABLE III

Interval Number	Gross Average Ash withdrawn from Digestors
3	20,910 lb. per day
4	17,730 lb. per day
5	20,130 lb. per day
6	22,630 lb. per day
7	20,100 lb. per day
Average	20,680 lb. per day
Less Ash in Seed Sludge	4,490 lb. per day
Net Ash	16,190 lb. per day

content of sludge is indestructible in the digestion process. It may be noted that the daily average quantity of ash withdrawn is 16,190 lb., and this figure represents the quantity of ash added with new sludge daily during the period.

TABLE IV—DAILY ADDITION DRY SOLIDS PER DAY IN RAW SLUDGE

	Primary Sludge	Activated Sludge	Total
Lb. of ash	8,130	8,060	16,190
of volatile	17,670	21,870	39,540
Total	25,800	29,930	55,730

Suspended Solids in Raw Sewage

Ash	139 p.p.m.
Volatile	360 p.p.m.
Total	499 p.p.m.

A daily plant analysis is made of the solids content of supernatant liquid from primary clarifiers and a like analysis of the effluent from the secondary clarifiers following the activated-sludge process. Coupled with the ash determination of the digested sludge and the weighted average analyses of 25 samples of raw sludge during the period of observation, it is possible to calculate the pounds per day of solids added to the digestion tanks. This results in a total of 55,730 lbs. of dry solids added to the digestors daily in the raw sludge, of which 39,540 lb. is volatile and 16,190 lb. fixed. A further incidental calculation indicates that the average suspended solids content of the raw sewage entering the plant is 499 p.p.m. plus any bar screenings removed.

The net designed capacity of each of the eight digestion tanks included in the two batteries is 28,056 cu. ft. Soundings were made in each tank to determine the depth of sand accumulated in the 2-year operation period. In Tank No. 1 the depth averaged 12.9 in.; No. 2—10.2 in.; and No. 3—5.3 in. There is no accumulation of sand on the floor in Tanks No. 4 because these tanks are frequently completely emptied direct to the beds. The capacity of batteries is reduced at the present time by the depth of this sand layer.

TABLE V—EFFECTIVE CAPACITY AND DETENTION PERIOD
BATTERIES A & B

87% effective capacity—all tanks	=	1,459,000	gal.
Seed and raw sludge pumped per day	=	154,000	gal.
Average period of detention—no supernatant liquid withdrawn	=	9.5	days
Average flowing-through period—by NaCl determination	=	9.8	days
Average detention time of solids in batteries	=	14.7	days
Average detention time of solids, weighting for supernatant liquid withdrawal	=	15.2	days

A further reduction in capacity is apparent in Tanks No. 4, because, while these tanks are under a pressure of about 0.5-lb., the adjacent sludge-storage well is under atmospheric pressure only and the elevation of the sludge surface is correspondingly depressed. Furthermore, during the test period Tanks No. 4 were operated on the fill-and-draw method and the overall capacity of the two batteries was correspondingly reduced. The net result is that during the test period, the effective capacity of the tanks was 87% of the designed capacity, or 1,459,000 gal. From April 27 to May 15, no supernatant liquid was withdrawn, therefore, disregarding the weight or bulk of material removed as gas, the overall detention period in the batteries becomes a simple division of the effective tank capacity by the quantity pumped to the tanks per day, and results in 9.5 days as the average overall detention time for this period.

To check results as to time of detention, NaCl was added in Tank No. 1 of Battery A and its rate of travel through the battery determined by analysis of the digested sludge for chlorides in excess of normal. Although not particularly accurate, the results indicated about 9.8 days as the net time of detention.

Detention time of solids in the tanks was made by analysis of the contents in each tank, coupled with analysis of the digested sludge and supernatant liquid. From this it was disclosed that solids concentration in the tanks was 1.55 times that in the digested sludge, indicating a lag in solids and a detention time of 14.7 days. When supernatant-liquid withdrawal is considered in Tank No. 3, the average time of solids detention is increased to 15.2 days.

An analysis of the upper strata in the tanks indicates that the period of detention of some materials is many times this interval. Seasonal seeds were present which had probably been in the scum formation for many months. The interesting comparison is that without particular attention in operation, solids are retained in the tanks an average of 14.7 days in spite of the fact that the overall capacity indicates but 9.5 days.

The digestion plant efficiency is probably best indicated by the volatile solids reduction during the elapsed detention period. During the period of examination, primary and activated sludge entered the tanks daily containing 39,540 lb. of volatile material, to which was added the seed-sludge volatile component of 4,560 lb. The digested

TABLE VI—VOLATILE SOLIDS REDUCTION

	Sludge Entering Tanks			Digested Sludge Leaving
	Primary & Activated Sludge	Seed Sludge	Mixture	
Volatile content, %	71	50.4	68.1	52.9
Volatile content weight, lb.	39,540	4,560	44,100	22,900

Lb. of volatile solids reduced — 21,200 or 53.7%
Digested sludge: % Volatile = 52.9 % Ash = 47.1

sludge leaving the process daily contained 22,900 lb. of volatile solids, indicating a reduction of 21,200 lb. or 53.7% during the interval of digestion. Digested sludge removed from the tanks to drying beds had an average volatile content of 52.9% and an ash content of 47.1%.

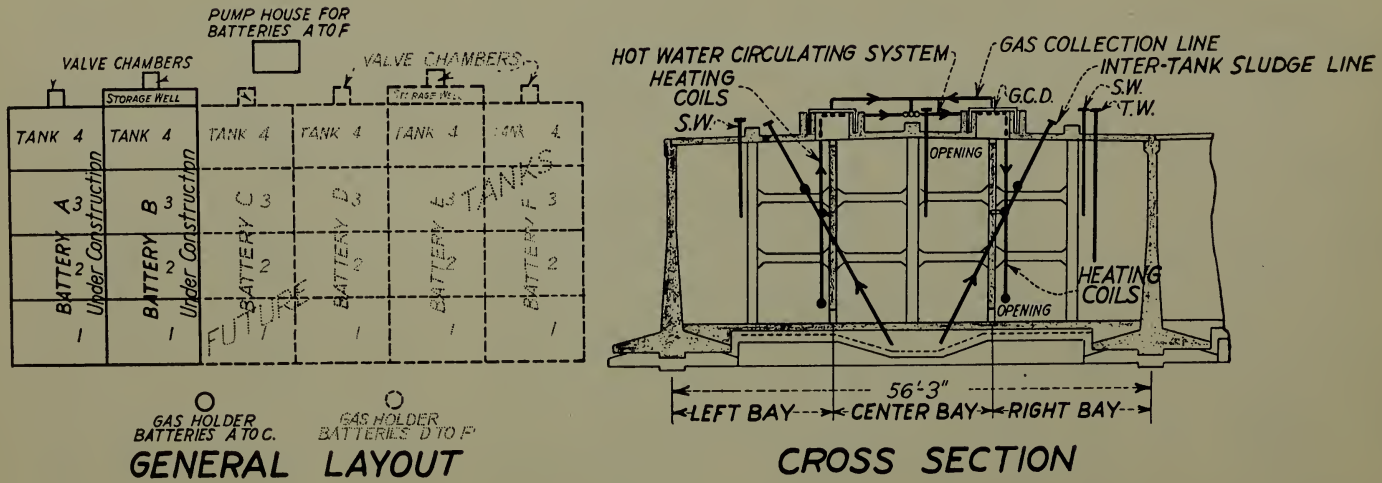
For the purpose of demonstrating the drying characteristics of the digested sludge, Bed No. 12 was filled to a depth of 14 in. on August 9, 1933. The bed had just been re-sanded and was not perfectly level. Determinations of moisture content at varying intervals were made in one of the slight depressions, so that results do not exaggerate conditions for August drying weather.

In 20 hours elapsed time the sludge depth had dropped to 6¾ in. and the surface had commenced to crack. At the expiration of 45 hours, the sludge depth was 5 in. and the sludge surface had opened up with typical evaporation cracks. Sixty to seventy per cent of the sludge could have been removed from the bed and run through the macerater in 14 days but that in the bed depressions was not ready for removal for 19 days, at which time it was ridged ready for final grinding and removal to the orange groves.

Digested sludge as it reaches the beds has the typical tarry odor, drains readily, dries with reasonable dispatch, and does not breed house-flies.

TABLE VII—SLUDGE DRYING EXPERIMENT
(Weights calculated to 1 gram of solids originally present)

Days	Weight of solids remaining	Assuming no evaporation			Actual conditions		
		Weight of water	Percent original water remaining	Percent moisture of sludge	Weight of water	Percent original water remaining	Percent moisture of sludge
0	1.000	28.0	100	96.55	28.0	100	96.55
1	0.966	14.5	53	93.74	13.0	46	93.10
2	0.959	12.3	44	92.78	9.4	34	90.74
3	0.959	12.0	43	92.65			
6	0.959	11.7	42	92.42	2.97	10.6	75
9	0.959				2.02	7.2	68
19	0.959				1.22	4.4	56



Multi-Stage Sludge Digestion Tanks at Joint Disposal Plant of Los Angeles County Sanitation Districts.

(For Plan of Battery B and Longitudinal Section of Battery A, see p. 15)

LEGEND: Gas Lifts—G.L.; Sampling Wells—S.W.; Port Holes—P.H.; Thermometer Wells—T.W.; Gas-Collection Domes—G.C.D.

From measurements of the rate of fall of the bed surface, drainage from the bed, and moisture content of the sludge, calculations have been made of the proportion of water which drains away and that which is lost by evaporation. Sludge was pumped to the beds at 96.55% moisture, or 28 parts of water to one part solids. Drainage alone, in one day's elapsed time, accounts for loss of nearly half the water, reducing the ratio to 14.5 parts of water to one part solids. By the expiration of six days, drainage has ceased but drainage plus evaporation has reduced the ratio of water to solids to 2.97 to 1. Evaporation alone accounts for the remaining removal to the proportion of 1.22 parts water to one part solids at the expiration of 19 days, or 56% moisture content in the deeper portions of the bed. Sludge may be removed, macerated, and transported to the orange groves at such moisture content.

The foregoing factors may also be resolved into a computation showing the weight of digested solids which can be dried upon a square foot of bed area in a year and the population equivalent thereof. For this deduction the average year-round drying time has been extended to 28 days instead of 19 days as indicated for August weather.

At 96.00% moisture content, 2.5 lb. of digested solids may be dried upon each square foot of bed area each 28 days, or 13 times per year, equaling 32.5 lb. This 32.5 lb. represents the digested solids from 52.5 lb. of raw solids prior to digestion. The population equivalent for bed-drying area on this basis is 1250 sq. ft. per 1000 connected, but it must be borne in mind that the sewage being treated is very strong and high in industrial waste. Nine hundred square feet per thousand connected would be more appropriate for a sewage of domestic origin only.

TABLE VIII—ETHER-SOLUBLE CONTENT OF SLUDGES

Entering:	Ether Soluble
Raw	4,590 lb. per day
Activated	5,960 lb. per day
Seed	640 lb. per day
Total	11,190 lb. per day
Digested sludge	4,070 lb. per day
Reduction	7,120 lb. per day

The reduction in ether-soluble material and the nitrogen balance are considered worthy of comment in this discussion. A daily load of 11,190 lb. of ether-soluble materials was pumped to the digestors during the period of observation. The ether-soluble content of digested sludge pumped daily to drying beds equaled 4070 lb., indicating a daily reduction of 7120 lb. out of a total volatile solids reduction of 21,200 pounds. Thus, 67% of the ether-soluble material pumped to the digestors was reduced. Strangely enough the at-

tempted digestion of 600 lb. daily of additional tank skimmings (largely grease) so upset the plant operation that it was discontinued. No definite reason is ascribed to this phenomenon, but the fact remains that while skimmings were pumped to the digestors, the resulting sludge would not drain or dry properly, and that upon discontinuance the digested sludge promptly assumed its original characteristics.

TABLE IX—NITROGEN CONTENT OF SLUDGES

	Nitrogen in Pounds per Day			N. % Dry Weight
	Water Soluble	Non-Soluble	Total	
Entering tanks:				
Raw			618	2.40
Activated			1,558	5.21
Combined	36	2,140	2,176	
Seed	226	307	533	5.9
Total entering	262	2,447	2,709	
Leaving tanks:				
Digested	1,065	1,483	2,548	5.9
Supernatant liquor	99	13	112	
Total leaving	1,164	1,496	2,660	

There is apparently no nitrogen lost in the digestion process, but sufficient is converted from non-soluble to soluble form and drained away with the sludge water to greatly reduce the nitrogen content of the dried digested material. Of the raw solids and seed entering the tanks, but 262 lb. of a total of 2709 lb. of nitrogen are water-soluble, while in the digested material 1164 lb. of 2600 lb. detected is water soluble. The difference between 2709 lb. measured daily into the tanks and 2660 lb. withdrawn is well within the limits of experimental error. The conversion of non-soluble to soluble nitrogen points to the possibility of the recovery of ammonium sulphate by distillation of the sludge liquor. For the plant under discussion, this would amount to 2200 lb. per day. Present low prices do not indicate its economy, however.

Supernatant liquid from the tanks is quite turbid, containing approximately 3100 p.p.m. total solids, about equally divided between suspended and dissolved. Fifty-seven per cent of the total solids are volatile, while the B.O.D. averages 450 p.p.m. The liquor is pumped onto a sludge bed reserved for this purpose and drains thence to the raw-sewage wet well. As it drains from the bed, it contains about

380 p.p.m. suspended and 1600 p.p.m. dissolved solids, 48% of the combined solids being volatile. B.O.D. of the bed drainage is 250 p.p.m. A small portion of Ammonia N. is lost—some 50 p.p.m. of a total of 550 p.p.m.

TABLE X—GAS PRODUCTION (QUANTITY BY STAGES)

Tanks 1 =	109,100 c.f. day =	41.3%
Tanks 2 =	63,920 c.f. day =	24.1%
Tanks 3 =	65,060 c.f. day =	24.6%
Tanks 4 =	26,400 c.f. day =	10.0%
Total =	264,480 c.f. day =	100.0%

Total including tank leakage = 271,700 c.f. day

Gas per gram of volatile matter destroyed	= 800	c.c.
Gas per lb. of volatile matter destroyed	= 12.8	c.f.
Gas per gram of volatile matter added	= 430	c.c.
Gas per lb. of volatile matter added	= 6.9	c.f.
Gas per capita connected	= 1.43	c.f.

Gas production was measured from each tank by installing meters on the gas escape in each manway and disconnecting the tanks from the main gas-outlet line. Production varied widely by stages—41.3% of the gas is generated in Tanks 1, 48.7% in Tanks 2 and 3, and 10% in Tanks 4. The total daily production of 271,700 cu. ft. equates to 12.8 cu. ft. per lb. of volatile matter destroyed and 6.9 cu. ft. per lb. of volatile matter added. Per capita connected production is 1.43 cu. ft. per day; but based on a population-equivalent of 0.15 lb. of volatile solids per capita per day, the gas production equals 1.03 ft.

Gas analysis of the composite of all tanks shows 65+% Methane; 33+% CO_2; 1.5+% Nitrogen; and 0.006+% H_2S. Practically all of the dissolved mineral sulphates disappear from the sludge in the first tank, but H_2S many times does not appear in the gas from this tank, the deduction being that the released H_2S combines with iron present to form iron sulphide, which may undergo subsequent change to release H_2S in the later stages of digestion. The calorific value of the gas is 630+ B.T.U. per cu. ft.

TABLE XI—COSTS

Total capital investment:	
Tanks and equipment	$131,983.26
Existing sludge beds	21,785.59
Required sludge beds	21,785.59
	$175,554.44
Annual interest charge at 5% =	$8,777.72
Annual tons digested sludge on basis of investigation	6,580
Interest charge per ton	$1.33
Operation charge per ton	0.96
Supervision, depreciation and replacements	1.12
Total per ton	$3.41

The two batteries of sludge digestion tanks, together with all incidental piping, equipment, and buildings, have cost the districts $131,983.26 to date. Twenty sludge beds, each 60 by 100 ft., have cost a total of $21,785.59. Twenty more sludge beds are needed.

Judged by conditions existing during the period of investigation, the interest charge (for existing plant plus 20 additional sludge beds) per ton of digested sludge based on a yearly production of 6,580 tons equals $1.33. Direct operation charges are $0.96 per ton and all other charges including depreciation $1.12. The total cost per ton, therefore, equals $3.41, the cost for sludge digestion per m.g. of sewage flow equalling $4.40. Most of the digested sludge is sold to a contractor for $2 per dry ton.

A. K. Warren is chief engineer of the Los Angeles County Sanitation Districts. The immediate investigation was accomplished largely by A. P. Banta and R. Pomeroy, research engineer and research chemist, respectively, for the districts under my direction.

SIGNS OF SEWAGE-MINDEDNESS IN THE SAN FRANCISCO BAY REGION

By L. C. MACABEE*

To one living on the Peninsula, signs of sewage-mindedness are more apparent today than for some time past. Cities, sanitary districts, and counties are contemplating work that has been delayed for years; work which in some cases would not be done but for federal or state aid.

Considering that there are some $6,000,000 of sewage works construction planned to go before the Public Works Administration for financing, in San Francisco and Oakland alone, the advance is significant. Whether or not it is only an imaginary boom, brought about by President Roosevelt's plea for a larger public works program and cheap money under the National Industrial Recovery Act, is difficult to say. A lot depends on the successful use of the California Sewer Revenue Bond Act in conjunction with the National Industrial Recovery Act, because with but few exceptions, all are counting on the federal government for financial aid—the voting of sewer bonds, in many cases, being out of the question. You have just heard C. C. Kennedy, in his paper, 'The National Industrial Recovery Act and Its Relation to the California Sewer Revenue Bond Act', give a very thorough discussion of what might be expected of these two bills. Their successful use would probably open up a tremendous amount of work, especially in cases where there are a number of adjacent sanitary districts and towns, any one of which,

* Deputy Engineer, San Mateo County, Redwood City, California.

alone, could not afford a treatment plant and long outfall, but combined, could do a great deal. But, until these bills have been tried, their value is only problematical.

Interest in sewage matters is particularly roused by two groups of citizens. One group has for its aim the creation of more jobs for the unemployed, the other a desire to take advantage of the offer made by the federal government through the National Industrial Recovery Act. An illustration of the first group is found in the San Mateo County Unemployment Bond Relief Committee, whose function is to give relief to the unemployed by putting them to work. The workers are allowed to earn a subsistence wage and so keep self-respect as American citizens. Because the primary purpose is relief, all are paid a common wage of $15.00 for a 35-hour week. The only limitations to the use of this unemployed labor in the county are: (1) the project must be of a constructive nature (maintenance work not being eligible); (2) that it be a public benefit (not private); (3) that it be adequately supervised; (4) that all material and other costs (exclusive of common labor) be furnished by the city, district, or county organization doing the work; and (5) that the work would not be done otherwise. In the past year the unemployed have helped to build a golf course, a number of drainage systems, water systems, roads, parks, fire trails, sewer outfalls, and—since the committee has widened its policy—sewer systems. This last is expected to help promote new districts for sanitary sewer systems and the extension of old systems to include newly built-up areas—in short the elimination of the septic tank and cesspool.

The other group, very active on sewage matters, are those officials who realize the opportunities opened to them by the federal government, to do some of the work which was programmed years back, but never done because of financial difficulties. They feel the advantage of a 30% grant, with the balance loaned at 4% interest, is something not to be overlooked.

Some of the forces calling for a clean-up of the San Francisco Bay shore line are: (1) The development of lands for residential, recreational, and sometimes industrial uses, on which or near which, raw sewage is now being emptied. San Francisco has found the crowding in of the residential districts and the increased demand for bathing beaches is again demanding recognition at Baker's beach and the Marina. We are given to understand they contemplate subsurface disposal plants with a high degree of treatment, estimated cost $850,000. Burlingame and San Mateo are faced with a like problem of odor and nuisance from their nine outfall sewers, and are planning intercepting sewers and disposal plants. Palo Alto has already begun to clean up her shores by voting bonds for a sewer outfall and disposal plant.

(2) The building of highways and scenic drives, close to the shore line (and the sewer outlets), is an advertisement to all who pass of the laxity in treatment of sewage wastes. The Bayshore

highway from San Francisco to San Jose is a good example, especially at low tide.

(3) An increased demand for local oysters, once a $1,000,000 industry in the San Francisco bay, may also call for treatment in such places as South San Francisco, San Bruno, San Leandro, and Hayward.

(4) An active county planning commission is also in a position to do some real ground work on sewage matters, as is demonstrated in San Mateo county. On February 18, 1932, this commission put into effect a land sub-division ordinance, which requires that a complete and satisfactory sewerage system be installed before the property is placed on the market, thus assuring an adequate collection system before the district is built up. Now a tentative land-use plan is being laid out for the county's 24 mi. of bay shore line. That property from the San Francisco municipal airport to the San Mateo-Hayward bridge, has been set aside for recreational activities—amphibian landing field, water-front recreational development, yacht harbor and amusement center, municipal golf course, and such—the remainder of the shore line being set aside for industrial uses. This zoning, besides being an aid to the designing sanitary engineer, gives the public a chance to visualize the future land development and become educated to the need of sewage treatment plants.

(5) The Bureau of Sanitary Engineering, State Department of Public Health, also has a major part in this problem of sewage disposal in San Francisco bay.

(6) And finally, under the heading of special circumstances, we might repeat the N.I.R.A. and the Unemployment Relief bonds voted by the cities and counties of the bay area. The impetus given by these measures is the same. They are intended to lighten the load of financing, and thereby open up the marginal type of project, i.e., those projects that were needed, but were not absolutely essential to the health and welfare of the community.

Some of the recent signs that show an awakening of sewage-mindedness on the Peninsula follow:

In 1928 the San Francisco Chamber of Commerce, in making its report on the possible consolidation of San Francisco and San Mateo counties, gave as one of the advantages cooperative planning and financing of adequate sewers and sewage disposal plants. This is thought to be the first written article that even hints towards a comprehensive plan of sewage disposal for the west side of the bay.

Several months ago the Sanitary Division of San Francisco Section, American Society of Civil Engineers, met in San Francisco for an engineering discussion of 'Sewage Disposal in the San Francisco Bay' and carried this thought one step further and said that the only way the bay frontage can be cleaned up is by concerted action of all cities and counties fronting on the bay.

About the same time the Peninsula League of Municipalities met for a general discussion of projects to go before the PWA; in which

sewage disposal took a very prominent part. At that time they appointed a committee of the mayors and engineers of the peninsula, San Francisco to Palo Alto inclusive, to discuss the possibilities of a master plan of sewage disposal for the whole peninsula. The meeting of the committee at Palo Alto, after some discussion, finally broke up over the point of financing such a comprehensive study. Thus the problem was left up to the individual cities and sanitary districts.

As previously mentioned, the sewage question in San Mateo county received new attention when the scope of the work done by the Unemployment Relief workers was widened to include construction of sewers and sewage disposal plants. This method of laying sewers is costly, when machine trenching is compared to hand work with the pick and shovel, but to a district contemplating sewer construction the offer of free labor is a real advantage.

The disposal plant at Palo Alto, for which materials and equipment have already been purchased, is the first real step taken towards cleaning up the west side of San Francisco bay. The long outfall, discharging 700 ft. from shore, preceded by a clarifier, coarse screening, and separate sludge digestion, is planned to amply protect Palo Alto's proposed recreational center.

If the Burlingame and San Mateo projects are received favorably by the PWA, that section of the bay will be cleaned up. The same thing is true for San Francisco's two disposal plants at Baker's beach and the Marina.

In the southern end of the peninsula, the County Engineer's Office is making a study to combine the sewage from all of the area between the Palo Alto line to and including Redwood City, at one central disposal plant for treatment. The problem is quite involved, both from a legal and financial standpoint, as it includes several cities, sanitary districts, improvement districts, and districts outside; but the interest shown is very heartening. The work, if done, will probably be under the California Sewer Revenue Bond Act and the N.I.R.A.

In conclusion, indications are that interest in sewerage and sewage disposal has made a decided turn for the better, although the East Bay does not appear as active as the peninsula. Whether this advance can be laid to the N.I.R.A. or not, the fact remains that the general public, the city councils, the sanitary boards, and the boards of supervisors are becoming more and more interested in sanitation.

REMOVAL OF AMMONIA FROM SEWAGE BY ZEOLITE

By M. J. CONOVER[1] and O. C. RALSTON[2]

Recent technical literature and pilot plant trials, involving ammonia recovery from sewage, have increased the demand for information on the behavior of the ammonium ion toward base exchangers. Synthetic zeolites are the most efficient base exchangers for the reaction involved and are therefore the subject of discussion in this paper.

The best base-exchanging zeolites are a class of substances having the general chemical formula $R_2O : Al_2O_3 : n\ SiO_2 : mH_2O$; R is the exchangeable base or cation; the value of n varies from 2 to as high as 20 mols, although there is doubt as to whether the silica in the zeolites with over 10 SiO_2 mols is actually combined in the zeolite complex; the value of m is usually about the same as the n, i.e., the number of mols of water of constitution or crystallation are the same as the mols of silica. The usual product of commerce is sodium zeolite; here the cation R in the formula is sodium, Na, and the remainder of the complex is the anion.

When a solution of a salt, containing an exchangeable cation, comes in contact with a zeolite, the exchangeable ion of the zeolite is replaced by the exchangeable ion of the salt in solution. This is simply illustrated when a hard water passes through a zeolite bed; the calcium and/or magnesium in the water base exchanges with the sodium of a sodium zeolite.

Lithium, Li, is the most easily displaced monovalent element that has been attached to a zeolite complex, the next two in order being sodium, Na, and the ammonium radical, NH_4; of the bivalent cations, magnesium, Mg, and calcium, Ca, are the most easily displaced, in the respective order given.

The efficiency of base exchange, under constant conditions, depends on equilibrium, or the ratio of the exchangeable cations in solution to the exchangeable cations of the zeolite. For example: in water softening with sodium zeolite, the efficiency of base exchange decreases as the alkali salts in the water being treated increase. The effect on base exchange involving ammonia with calcium, magnesium and sodium is not fully determined at this time; however, from certain behaviors it seems quite evident that ammonium zeolite is less stable than calcium or sodium zeolite. We, therefore, would anticipate lower base exchange efficiency with ammonia than with calcium or magensium; i. e., less ammonia, quantitatively per unit of zeolite volume, would be removed between regeneration periods than is now common practise with calcium and magnesium.

[1] Manager of western sales and production, Arizona Minerals Corp.
[2] Technical director, Arizona Minerals Corp.

Hydrogen-ion Concentration—Most raw sewage has a pH value of less than 7.0, due to carbon dioxide and other acids. Waters having a pH value on the acid side tend to irreversibly convert synthetic zeolites to hydrogen zeolite, and may eventually destroy the zeolite structure. Pretreatment should, therefore, include maintaining a pH value of from 7.4 to 8.0 in order to protect the zeolite bed.

Recent experiment on the final activated-sludge effluent at the Griffith Park Experimental Station, Los Angeles, has demonstrated the fact that water carrying 250 p.p.m. $CaCO_3$ equivalent reduces the efficiency of ammonia-nitrogen removal, where sodium zeolite was in service. Our first tests indicated an ammonia-nitrogen removal of about 40%. However, by converting the zeolite to a calcium or calcium-magnesium zeolite, the results were very encouraging; a 10-hour test indicated a maximum ammonia-nitrogen reduction of 95% and a minimum of 71%, the average being 80%. This experimental work is being continued.

A process, as described by Smith[3] and by Gleason and Loonan[4] involves coagulation with a ferric salt and lime, followed by sedimentation; the clear effluent is passed through a bed of synthetic sodium zeolite, or sodium-calcium zeolite, or calcium zeolite. They report having obtained an ammonia-nitrogen reduction of as high as 93%.

In the work cited, the sodium or calcium cation of the zeolite base exchanges with the ammonia-nitrogen radical, forming insoluble ammonium zeolite, and the sodium or calcium combines with the anion in solution. Representing the complex anion of the zeolite by the symbol Ze, the exchange is easily understood in the following chemical equation:

$$\text{(a)}\quad Na_2Ze + 2NH_4Cl = (NH_4)_2Ze + 2NaCl$$

The zeolites of calcium, magnesium, sodium, and ammonium are all practically insoluble in water, yet they will react rapidly with solutions of soluble salts that contact them. When a zeolite mass becomes saturated, the ammonia-nitrogen may be base-exchanged out by regeneration with salt brine. This reaction may be expressed in the following chemical equation:

$$\text{(b)}\quad (NH_4)_2Ze + 2NaCl = Na_2Ze + 2NH_4Cl$$

In equation (a) the concentration of the soluble salts is very low; this condition is reversed in equation (b) as mass action is required for efficient regeneration.

The ammonia may be recovered from the ammonium chloride of the brine as liquid ammonia or aqua ammonia by boiling the brine with lime in the regular ammonia still. The calcium and sodium chloride solution may then be returned and built up for reuse in subsequent regenerations of the zeolite.

[3] 'Water Works and Sewage', Vol. 79 (1932) p. 420-422.
[4] 'Water Works and Sewage', Vol. 80 (1933) p. 50-32.

Many factors influence the ammonia content of sewage. The character of the sewage is important, whether domestic or industrial. The dilution of the material is important, also the time since it was deposited in the sewerage system; the temperature and the biological conditions and similar factors all contribute. Babbitt[5] gives some rough averages of ordinary sewage sampled at points not too near the source.

Strong sewage	50 p.p.m. NH_3
Medium sewage	30 p.p.m. NH_3
Weak sewage	15 p.p.m. NH_3

The average for the year just passed at the activated plant at Pasadena, was 20.1 p.p.m. NH_3 in the raw sewage. At the Griffith Park Experimental Station, the average for the last three years was 20.2 p.p.m. NH_3 for the raw sewage. Therefore, the minimum and maximum ammonia in sewerage systems may vary from 10 to 50 p.p.m. NH_3.

Value of Ammonia—While liquefied anhydrous ammonia retails in cylinders for over 10c per lb., ammonia gas at the plant of a producer is worth only about 4c to 6c. The huge synthetic ammonia plants in this country and in Europe probably have production costs at 3c per lb. for anhydrous ammonia and up. Fertilizer nitrogen must be sold for slightly over this figure and usually does sell for 4c to 5c under large contracts in depressed times; 6c is probably a normal price.

A million gallons of sewage may therefore be expected to have 75 to 400 lb. of recoverable ammonia, which at 5c per lb. has a value of from $3.75 to $20. A considerable profit is apparent to encourage better treatment of sewage.

Whether the market will absorb all the ammonia which might be produced from the nation's sewage, is an important question; however, for the pioneers it can be said that the market for some time to come will be ample. It is probable that marketing of sewage ammonia will always be able to compete with synthetic ammonia, and that if sewage ammonia should be generally recovered, the synthetic ammonia industry will need wait in its expansion until all sewage ammonia has been taken care of. We shall leave to others more competent to do so, the preparation of an exact estimate of the present and future use of ammonia and the probable total ammonia available in the nation's sewer systems.

From the study of prior literature on the subject of ammonia and base exchange, reports are found of instances where zeolites have been used to trap ammonia. In 1917, Folin and Bell[6] found that when urine and synthetic zeolite were shaken together, the ammonia was quantatively absorbed and it could be again quantatively liberated by treatment with sodium hydroxide. They utilized this fact in

[5] H. E. Babbitt, 'Sewerage and Sewage Treatment', John Wiley & Sons, New York, 1932.

a test for ammonia content in urine. This no doubt inspired Baker[7] in 1920 to use synthetic zeolite for preparation of ammonia-free distilled water and he installed a 'zeolite purifier' at the laboratory of the State Water Survey Division of the University of Illinois. Here synthetic zeolite completely removed ammonia from distilled water containing 0.7 p.p.m. NH_3; regeneration of the zeolite was done with salt brine. Baker had had this installation in use for two years at the time he wrote his paper. The above obscure applications of synthetic zeolite for ammonia recovery tend to support the suggestion that the field is still undeveloped and worthy of serious study and research.

Ammonium zeolites have been intensively studied by soil chemists; some of the early work on absorption of ammonia ions by zeolite in soils was that of McBeth[8]. Basic ammonium acetate or ammonium chloride solutions were regularly used in determining the base-exchange capacity of soils, as outlined by Schollenberger and Driebelbis[9]; also by Chapman and Kelly[10].

Summary—It is evident that the zeolite cycle in the recovery of ammonia-nitrogen is very similar to the zeolite cycle in removing calcium and magnesium in water softening.

The foregoing discussion has been confined mostly to fundamental principles. We believe it is evident there is a basis of fact to support the suggestion that ammonia recovery from sewage has economic possibilities; in addition it is important to improve the quality of the final sewage effluents.

The successful application of this base-exchange principle to sewage disposal would not only be a step forward toward better standards of final sewage effluents, but at the same time, the value of the ammonia so recovered would more than pay for the installation and maintenance costs of such a plant.

The possibility of applying the zeolite step to present effluents from aerobic and anerobic processes is attractive; however, there are many variants and at present there is needed a careful study of the various sewage disposal plants to determine the characteristics and form of the ammonia content at different stages of treatment. With such data available as a basis for calculation, each condition may be intelligently considered for maximum recovery and efficiency.

[6] 'Jour. of Biological Chem.', Vol. 29 (1917) p. 329.
[7] 'Jour. Ind. & Eng. Chem.', Vol. 12 (1920) p. 798-799.
[8] 'Jour. Agric. Research', Vol. 9 (1917) p. 141-155.

[9] 'Soil Science', Vol. 30 (1930) p. 161-175.
[10] 'Soil Science', Vol. 30 (1930) p. 341-406.

COMPARISON OF METHODS FOR DETERMINATION OF CHLORINE DEMAND OF SEWAGE

By A. C. BEYER*

The chlorine demand of a liquid may be defined as the quantity of chlorine used up chemically by oxidizable substances in the liquid under a given set of conditions. When chlorinating water, sewage, or industrial wastes, this demand must be satisfied before any residual or active chlorine can be maintained in the treated material.

As the demand is affected by a number of factors, such as the method of applying chlorine, the nature of the chlorine-carrying solution or substance, time interval between adding the chlorine and the residual chlorine determination, and the relationship between the quantity of chlorine added in excess of that required to satisfy the chlorine demand, the quantitative value of the demand will vary with different techniques of determination. Since we usually think of chlorine demand in practice as being the quantity of chlorine required to produce a definite residual at the time of testing, a working definition follows: "Chlorine demand is the difference between the total quantity of chlorine added to the chlorinated material and the residual remaining at the end of some definite interval of time, known as the contact period".

Chlorine demand data is of interest primarily in connection with determining required capacities of chlorinating equipment and for predicting the costs of chlorination.

Factors of Importance in Chlorine Demand Tests

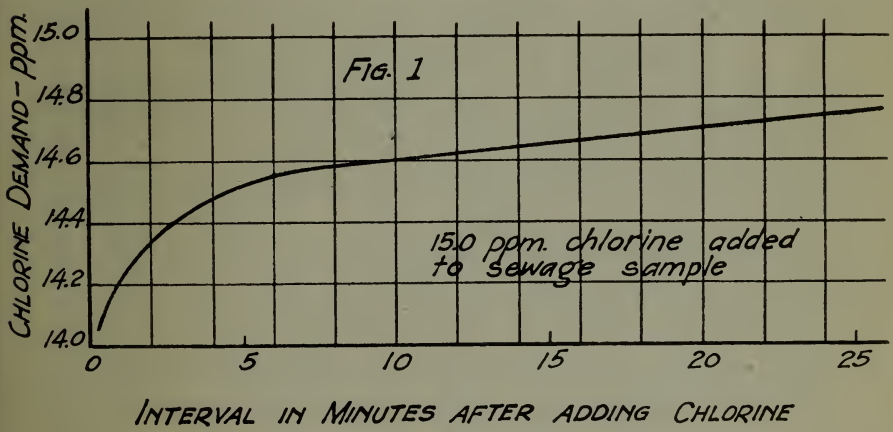
The effect of the interval of time between adding the chlorine and making the demand tests is shown in Fig. 1. The curve was derived from results of tests made on settled sewage having a chlorine demand of about 14½ p.p.m., to which 15 p.p.m. of chlorine was added. It is to be noted that the bulk of the chlorine represented by the chlorine demand disappears almost instantly; the increase in the absorption of remaining chlorine is fairly rapid during the first five minutes; but that thereafter the curve flattens out. It is obvious that more consistent determinations can be made after the rate of absorption of chlorine has slowed up. Therefore it is suggested that chlorine demand tests be made on the basis of a time interval of at least 10 min. If the conditions of the proposed use of chlorine call for a residual at the end of some other time interval, such as 20 min., then it is desirable that the effect of this time interval be kept in mind when making the demand tests.

While the general shape of the curve in Fig. 1 is accurate in illustrating the effect of the time factor, it is not to be taken as applicable quantitatively to every sewage. The residual involved and the slope

* District Manager, Wallace & Tiernan Sales Corp., San Francisco.

of the curve will change somewhat depending upon the strength, pH, temperature, and other characteristics of the liquid being dealt with.

Another factor of consequence is the technique employed in applying the chlorine to the sample when making the demand tests. If the standard chlorine solution used in making the tests is added to the sewage in 1-c.c. portions, with mixing and a short time interval between each addition, then the resulting chlorine demand, other factors being the same, will be less than the demand reading which would be secured by adding the same total amount of chlorine in a single dose. In plant operation, chlorine is normally added in a fashion more nearly paralleling its application in a single dose in the demand test, and therefore the single dosage procedure is to be preferred as the final test in case preliminary tests have been conducted otherwise for deriving an approximate demand value.



In plant practice a water solution of chlorine is normally used when applying the chemical. If a strongly alkaline hypochlorite, such as commercial bleaches, is used in making the demand determination, the apparent demand may be as much as 25% too low, because of its slower action. A chlorine solution made up by dissolving chlorine gas in water is theoretically preferable, but loses chlorine fairly rapidly and requires frequent check titrations for strength. A slightly alkaline hypochlorite introduces no serious error and consequently is to be preferred on account of its stability. Particularly is it advantageous for field use and greater dependability in transportation and handling.

Orthotolidin solution is definitely acid, and when added to a sample lowers its pH. Both the lowering of the pH and the reaction of the chlorine with the orthotolidin indicator affect the rate of absorption of chlorine by the sewage. Orthotolidin should therefore not be added to the sample until one is ready to make the color comparison promptly thereafter.

Perhaps the most important factor to keep in mind is the relation of the total amount of chlorine added, to the chlorine demand. The effect of this is shown in Fig. 2. The demand of this particular sewage might be read at any point between 14 and 22 p.p.m. if the determination was made without regard for the magnitude of the residual. The curves, drawn for tests on a settled sewage, taken 10 min. after the chlorine was added, show that it is essential that the desired residual in a proposed plan of chlorination be kept in mind when making chlorine demand tests.

If the factors mentioned are kept in mind it is possible to get good results with most of the published methods for chlorine demand. I believe, however, that there is need for a more definite procedure, and preferably the adoption of a standard procedure in order that various determinations can be better correlated. A suggestion along these lines follows.

Comparison of Recommended Procedures

Comparator Method—The first procedure will be called the comparator method. To a measured sample of sewage add a chlorine solution or slightly alkaline hypochlorite solution of known strength, sufficient to give a small residual at the end of a given time interval. At the end of this time interval, by means of a suitable comparator, proper color standards, and the addition of orthotolidin to the sample to produce the yellow color for comparison with standards, the residual chlorine is determined. The chlorine demand is taken to be the difference between the total chlorine added and the residual. If a suitable comparator is available, this method is accurate and simple.

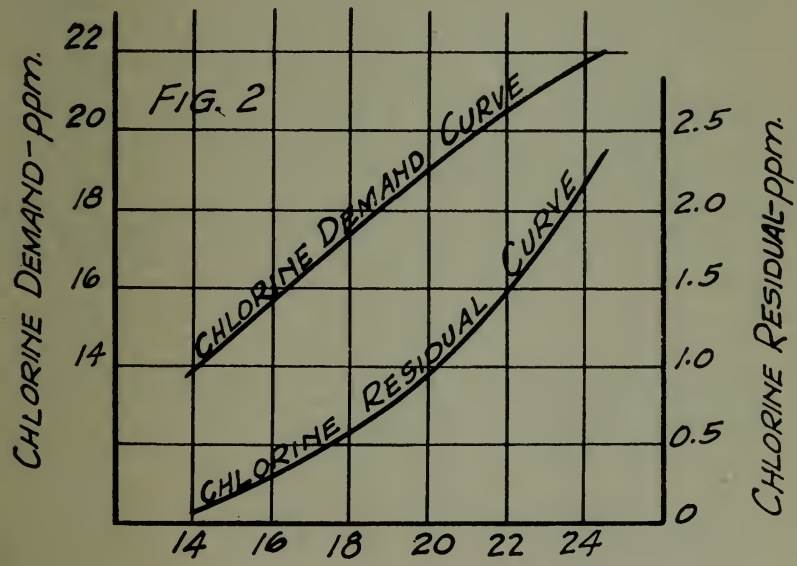
It has been suggested by some authorities that this method is not applicable to a sewage of high turbidity, but I believe that the objection would not apply with modern comparators. This method has the advantage that the procedure used in measuring residual chlorine is the same that is normally used in plant practice. The approximate demand may be arrived at by gradual additions of the chlorine solution. The final test is to be made by adding the solution rapidly at one operation, with stirring.

Series Method—The second method I will refer to as the orthotolidin series method. To a series of equal samples of sewage, various amounts of standardized chlorine solution are added, such as 1 c.c. to the first, 2 c.c. to the second, etc. At the end of a given time interval, such as 10 or 15 min., orthotolidin is added to a small portion of each of the samples. The chlorine demand is normally recorded as equal to the amount of chlorine added to the first sample which, upon test, shows a positive but faint yellow color.

By repeating the test and decreasing the difference between each amount of chlorine added to successive samples, any desired degree of accuracy can be secured with this method. This procedure has the advantage of not requiring comparator equipment, and possibly

the only objection would be the necessity of using a number of containers. Even though the approximate chlorine demand of the sewage is previously known, at least four samples are required to get satisfactory results.

Starch-Iodide Method—A third procedure I will call the starch-iodide method. In this determination the same original procedure of adding increasing amounts of chlorine to equal samples of sewage is followed as in the preceding method. At the end of 10 to 15 min., a few c.c. of potassium iodide solution is added to each sample, followed by a few c.c. of starch solution. It has been my experience



that this test is a very sensitive one, in that the first trace of the blue color, indicating at least a trace of residual chlorine, gives a chlorine demand which is appreciably lower than in other methods. Particularly is this true when acid is used in making the test, and therefore neutral solutions should be used. However, if the faint colors are ignored and the first definite blue color is read, the results will be very close to those which would be secured by the previous methods.

This method should only be used after an operator has checked it against other methods and determined the degree of blue color which should be read to give the chlorine demand. It is possible to make up color standards, but this procedure is troublesome and rarely justified. This method has the disadvantage of requiring a number of containers and therefore a relatively large volume of the sewage sample, and also requires two indicator solutions, neither of which keeps well.

Spot Plate Method—A fourth method is that involving the use of a spot plate. This method was originally developed by L. H. Enslow of the Chlorine Institute. The so-called spot plate is a piece of white tile, porcelain, or a china plate which has been covered with a thin coating of melted paraffine. White oil-cloth also serves for a time. This makes it possible to place on the spot-plate small drops of orthotolidin solution which stand up in a globule form, thus catching the maximum amount of light. To a measured sample of sewage add a standardized chlorine solution rapidly until the end point is approached, then add the remainder in increments of say 1 c.c. After the addition of each increment of chlorine, a few drops of the chlorinated sample are transferred to a globule of orthotolidin on the spot plate. The first appearance of a faint but unmistakable yellow color. which may rapidly disappear thereafter, indicates the end point and the chlorine demand is recorded as the total amount added.

The end point is checked again after a 5-min. contact, using a larger test portion of the sample.

From what has been said before it might appear that this method would introduce errors due to the time factor and method of adding the chlorine solution, but the procedure has the recommendation of having been tested out and of giving reliable results. In any event it offers a very quick and accurate method of determining the approximate chlorine demand, and if more accurate results are required it can be followed up with the orthotolidin series method, employing a comparator for greater exactness, if such be available.

Los Angeles Method—A year or so ago in connection with plans involving a rather extensive chlorination program, F. D. Bowlus and A. P. Banta of the Los Angeles County Sanitation Districts, developed a rapid field method, which for conditions encountered checked very closely with subsequent operating results. In this procedure. to a measured quantity of sewage a definite quantity of chlorine water is added, followed by orthotolidin solution. The selection of the quantity of sewage is determined either by an approximate knowledge of the chlorine demand or by a cut and try procedure until a distinct yellow color is produced. More sewage is then added gradually but promptly until the yellow color is dissipated. The chlorine demand is then readily calculated from the amount of chlorine added and the initial volume of sewage taken plus that required to blank out the color. In this procedure the volume of sewage required to blank out the color must be less than 20% of the initial volume of sewage; otherwise results are high. The reason for this stipulation, I believe, is explained by Fig. 2. In using this method it has been my experience that it would be essential that the operator check his technique against one of the other methods, particularly to judge color changes when blanking out the yellow color to reach the end point. This method illustrates the possibilities of developing simplified field techniques to fit particular cases in which the minimum of equipment is desirable.

I believe it would be highly desirable that a standard method for determination of the chlorine demand of the sewage be decided upon by the A.P.H.A. and A.W.W.A. committees. It appears to me that the orthotolidin series method would be a very good one with definite recommendations such as:

1. Use only chlorine water solution or hypochlorite solution of low alkalinity.
2. Use definite time interval between adding chlorine and adding orthotolidin to samples; suggested time interval of 15 min.; etc.

With this procedure I am confident that consistent results could be secured under widely varying conditions and thus give chlorine demand readings which would have universal significance. A very similar standard procedure could be based on the comparator method.

A standard method for chlorine demand in sewage if adopted would have to be varied in certain special cases such as where high residuals were to be carried in a projected plan of chlorination. In such special cases the standard method could be varied to suit the requirements. Nevertheless, in all cases the determination by the standard method would be a definite value to which other special readings of chlorine demand could be referred.

Field Practice

In field procedure it has been found that Zonite, if purchased in a drug store where there is a fairly rapid turnover of goods, runs consistently close to 1% available chlorine, or 10,000 p.p.m., and is of uniformly low alkalinity. Therefore, if facilities are not at hand for preparation of a standardized chlorine solution, Zonite diluted with distilled or even tap water is a very convenient source of chlorine solution of known strength. A solution thus made up of 100 or 200 p.p.m. strength, if handled with any kind of care is stable for two or three days, but should preferably be made up fresh daily. It should not be forgotten, however, that this is a short cut only and is not to be used where accurate results are desired.

Partial Chlorine Demand Determination

A new phase of chlorine demand of sewage has been pointed out by A. E. Griffin of the Wallace & Tiernan research laboratory. This Griffin has named the hydrogen sulphide chlorine demand. It is of especial interest where chlorine is used for odor or hydrogen sulphide control. The so-called hydrogen sulphide chlorine demand is really that which is necessary not only to neutralize the hydrogen sulphide in the sewage, but also enough to eliminate or retard bacteria of the reducing type which are active in the formation of this objectionable gas. Considerable plant experience has shown that this hydrogen sulphide demand is normally appreciably less than the total chlorine

demand revealed by the tests described above and is therefore not determinable by these tests.

Griffin has found that a variation of the standard methylene blue stability test as applied to sewage effluents is an excellent measure of the hydrogen sulphide chlorine demand. As an example, if hydrogen sulphide were to be eliminated in a treatment plant or an outfall sewer in which the time of flow was, say, four hours, then the hydrogen sulphide chlorine demand would be that amount of chlorine which would give a methylene blue stability for approximately that period, although preferably for a slightly longer period. Due to the growing use of chlorine for hydrogen sulphide and odor control the development of this special concept of chlorine demand and the tests for it should prove of decided value.

I am indebted to Benjamin Benas of the San Francisco City Engineer's office for assistance in securing confirmatory data for this paper, and to the officials of the Golden Gate Park Treatment Plant for the use of their laboratory, and to A. E. Griffin of the Wallace & Tiernan research laboratory, and L. H. Enslow of the Chlorine Institute, for suggestions in connection with the preparation of this paper.

Plan to Attend the

SIXTH SPRING MEETING

California Sewage Works Association

Yosemite National Park

May 25-26, 1934 (tentative date)

Headquarters: Camp Curry

TROUBLES WITH UTILIZATION OF SEWAGE GAS

By ALVA J. SMITH*

As a rule the utilization of any waste product is commendable. Odors that are given off in the operation of sewage treatment works have been a cause of offense to many generations in the past. The conversion of the offensively odorous and repulsive gases that are generated at such plants into non-odorous compounds by burning, and converting the heat generated in the process to beneficial use is certainly a worthy objective.

In speaking of the operation of modern plants we often hear the remark that "The ill-smelling gases are all collected and burned; the heat generated in the combustion process is used to heat residences, to increase the efficiency of digestion tanks, and for the development of power to drive air blowers and other machinery". This doubtless is a broad statement of a commendable purpose; but did you ever try it?

Development of power from sludge gas or even heating digestion tanks with it, is no simple matter. The complexity of the problems involved are soon realized by those who attempt to utilize the gas. However, the destruction of odors, and the economy that can be effected by conserving the heat values that are in the gas, are sufficient guarantees that burning will be continued. Improvements in the present more or less unsatisfactory methods of handling and burning are now being devised.

Characteristics of Gases—The gases that are generated in sewage treatment are necessarily complex. Many of them are not only odorous and obnoxious, but some are extremely corrosive as well, and sooner or later will destroy any ordinary apparatus in which they may be collected and burned. Even after these gases are burned, the products of combustion continue their vigorous attacks upon metal, paint, concrete, or other building materials with which they are allowed to come in contact.

The sludge digestion gases that have a peculiarly disagreeable odor are hydrogen sulphide (H_2S), phosphine (PH_3), indol (C_8H_7N) and sketol (C_9H_9N). The quantity of these odorous gases is very small, usually amounting to only a fraction of one per cent of the whole. The incombustible gases are mainly nitrogen (N) and methane (CH_4), with sometimes small amounts of ethane (C_2H_6) and ethylene (C_2H_4). The average methane content of 12 samples of sludge gas was 72% of the whole. The gas has a fairly high heating value, around 700 B.T.U.

Difficulties in Burning—Little difficulty has been experienced in burning the gas in the open, but when the necessary refinements for

* With Black & Veatch, Consulting Engineers, New York, Kansas City, Pasadena.

controlling combustion for heat development are introduced, various difficulties are encountered.

Of the gases that cause the most trouble from odors and corrosion, hydrogen sulphide is by far the greatest offender. The amount of this gas contained is always relatively small and often is entirely missing. According to a report issued by the U. S. Bureau of Mines, a hydrogen sulphide content of 0.1% will produce some injury to internal combustion engines and quantities exceeding this amount "do considerable harm".

By careful oiling and a little extra care on the part of the operators, a gas engine at Rockville Center, N. Y., has been operated for 3 years on sludge gas with little difficulty. It has been necessary, however, to remove carbon occasionally and to renew the spark plugs about every 6 weeks.

Examples of Corrosion—The combustion products derived from the burning of sludge gas at the Los Angeles experimental plant were so corrosive that they completely destroyed a cast-iron boiler in 3 years. At the end of that time the boiler literally fell to pieces. At Pomona a cast-iron boiler is enclosed in a housing of copper-bearing, lead covered, steel plate. After 6 months service the housing is practically unaffected, while the cast-iron is becoming seriously corroded.

At Escondido, most of the sludge gas is burned in the open, but a portion of it is used to heat the residence of the plant superintendent, which is located on the grounds. No difficulty has been experienced in heating the residence, but when an attempt was made to cook with the gas it was found that facilities were lacking for accurately controlling the gas pressure and the mixture of air and gas. This accurate control is very necessary to insure complete combustion and the consequent destruction of odors. As long as a proper mixture could be maintained no odors were noticeable, but a slight fluctuation in pressure would allow some of the unburned gas to escape, with results that were disastrous to the cooking.

Some Causes of Difficulties—The rate of production of gas in a sludge digestor is very erratic; the volume being produced may change perceptibly in a few minutes. Therefore when it is intended to use the gas for power purposes it is the usual practice to install a gas holder on the line to smooth out the flow. A holder of large capacity is not required unless storage of a large quantity of gas is desired. More or less scum from the digestor is usually carried over with the gas. In order to prevent clogging of meters, flame traps, and burner orifices, this scum should be trapped and drawn off; preferably by a mechanism or appliance that will act automatically.

Sludge gases as they are generated carry a large amount of water vapors. The gas at the Pomona plant carries the vapors from practically 1 qt. of water for each 1000 cu. ft. of gas.

A test of the moisture content was made by cooling 3.2 cu. ft. of the gas from 83°F. (the normal temperature as it leaves the tank)

to 32°F. The condensate amounted to 2.1 c.c., or 0.66 gram per cu. ft. of gas. As the weight of the gas was 30 grams per cu. ft., the water recovered amounted to 2.2%, which would indicate a total water content of 2.6%.

This moisture interferes with combustion. It lowers the temperature of the flame slightly, and joins with the much larger quantity of water that is produced in the combustion process and condenses on the boiler housing and flue unless a high temperature is maintained. A considerable amount of heat is lost in evaporating this condensate before the temperature of the boiler can be raised to a satisfactory degree. Passing the gas through cooling coils and bleeding the water off before it reaches the burner is one way of disposing of this excess moisture before it can do any harm.

Another way of avoiding trouble from moisture in the gas is to arrange the piping leading to the heating coils in the digestor in such a way that it is possible to operate the boiler at a much higher temperature than the coils, and thus prevent condensation on the boiler and housing. Even with this precaution taken, the moisture will condense in the flue and run down and stain and corrode everything it comes in contact with. About 12 gal. of water is produced in burning the hydrogen compounds that are contained in 1000 cu. ft. of gas. To prevent destruction of the flue by disintegration of the mortar joints, a fire-clay flue lining should be used and a cast-iron removable drip pan should be provided at its base for collection and removal of condensate.

Cause of Corrosion—In the making of sulphuric acid, sulphur compounds are burned and the fumes passed through live steam containing oxides of nitrogen. In the burning of sewage gas we have all of the necessary elements under almost ideal conditions for the production of sulphuric acid. Sulphur, nitrogen, oxygen, heat, and steam are all present and the formation of sulphuric acid is an inevitable result, according to the formula $H_2S + 3O = SO_2 + H_2O$. $SO_2 + O + H_2O = H_2SO_4$. The acid contained in products of combustion of sludge gas accounts at least in part for their extremely corrosive nature. Under the action of these gases copper, brass, steel, and even cast-iron are seriously attacked.

Corrosive-Resistant Metals—The draft hood of the incinerator at Whittier's sewage disposal works is made of allegheny metal, an alloy of iron, chromium, and nickel. This has stood the action of the heated fumes for 2 years without signs of deterioration.

At Pomona, the heating coils and all piping carrying sludge gas is of Toncan steel, an alloy of pure iron, copper, and molybdenum. Before this material was adopted at Pomona instead of wrought iron as specified, an accelerated test of a sample of the Toncan pipe and one of genuine wrought iron was made. Samples of equal weight and practically equal surface area were placed side by side in 10% sulphuric acid. At the end of 14 hr. the wrought iron had lost 46% of its original weight and the Toncan only 0.3%. Tests indicated

that galvanizing of the Toncan probably acted as a detriment to its lasting qualities rather than a benefit on account of the electric currents set up by the action of the acid on the copper alloy and the zinc coating.

Explosions—Sludge digestion gases when mixed intimately with air in proportions ranging from 7 to 20% of gas to 93 to 80% of air are violently explosive. Precautions should be taken in the design and operation of plants to prevent these dangerous mixtures being formed. When such combinations are allowed to form, explosions are to be expected. There are so many ways for these explosive combinations to become ignited that it is extremely difficult to guard against all of them. Plant superintendents and operators should be particularly well informed regarding the explosive character of these gases when they are inclosed, and their high inflammability when subject to ignition in the open. Explosions of mixtures of gas and air when the gas component is around 12% are extremely quick and violent.

Many disastrous explosions have occurred about sewage treatment works and the danger of such an occurrence constitutes one of the troubles of those who are connected with the utilization of sewage gas.

For complete, odorless, and safe burning of the gas a practically uniform pressure must be maintained at the orifices of the burner. This uniformity of pressure is best secured by having a floating cover on the digestor or by a floating gas holder on the pipe-line leading from the tank.

Conclusion—While the burning of sludge digestion gases, especially for power production, may at this time be attended with some difficulties, there is nothing connected with the matter that will not yield to the application of scientifically directed engineering skill. It is therefore up to the engineer to make full application of his knowledge to this problem, and devise the best and most economical means of solving the difficulties involved and pass this information on to others, that the progress which is being made in general methods of sewage treatment may not be hindered by our failure to put an ill-smelling gas to a beneficial use.

DISCUSSION

T. R. Haseltine, in discussion, considered the paper too pessimistic as to difficulties in using sludge gas and felt that proper design and operating precautions would solve the problem. R. C. Pomeroy noted that most coal contains more sulphur than does sludge gas and this should not cause concern if combustion is right. Water content of average sludge gas is not excessive and condensed water in flues principally consists of products of combustion. C. F. Tennant found no special type of burner necessary for sludge gas and could correct flue plugging by use of forced draft. R. F. Goudey warned against using automatic temperature controls on burners, since with sludge gas condensation in the flues during shutdown would prevent satisfactory start and stop operation. J. J. Jessup believed that sludge gas presented no problem if proper types of gas burning and handling equipment were used and scrubbing towers provided in some cases, the same as when using coal gas. E. A. Reinke stressed the importance of adequate and proper gas-handling equipment and C. C. Kennedy mentioned the possible use of chlorine to keep down hydrogen sulphide content of the gas.

OPERATING EXPERIENCES, YOSEMITE SEWAGE TREATMENT PLANT

By RUSSELL C. WHITE*

The National Park Service completed a sewage treatment plant at the lower end of Yosemite valley during the summer of 1931. This plant, which was placed in operation August 8, 1931, is of the activated sludge type with separate sludge digestion. The plant proper consists of a covered primary sedimentation tank, four spiral-flow aeration units, two secondary settling tanks, one of which is used as a chlorine detention tank, four digestion tanks, a thickening tank, and glass-covered sludge drying beds. The plant was designed to treat a maximum flow of 1.224 m.g.d.

The sewage entering the plant is wholly domestic and usually arrives before becoming septic. The difficulties many operators face of treating trade wastes, of course, are not encountered.

One unusual condition is the monthly variation in flow. The flow depends, to a large extent, on the visitors entering the park. During 1932, for example, a total of 104.5 m.g. of sewage was treated, with a minimum monthly flow of 1.9 m.g. during December and a maximum monthly flow of 17.4 m.g. during June. The daily flow also varies considerably, especially during the winter season when most of the visitors spend only the week-ends in the park.

Clogging of the Porous Air Plates—During the spring of 1932, the porous air plates in two of the aeration tanks became clogged due, we believe, primarily to oil from an auxiliary compressor used because of mechanical trouble with the regular blowers. Also, the air had been shut off from the two tanks at frequent intervals during the preceding months and no doubt suspended matter passed into the plates and was a contributing factor to the clogging.

We tried many methods of cleaning and finally decided on the following: About a quart of confiscated 'bootleg' alcohol was passed through each plate and the plate allowed to dry. It was then heated with the flame of a blow-torch until the color turned a dark brown. This method proved satisfactory. Since cleaning, the tanks have had about a year's operation and no clogging is apparent. I might mention that we are now careful to maintain the air supply as continuously as possible to avoid any further trouble.

Change in Air Lift—The sludge return line to the aeration tanks as originally constructed was operated by a standard air lift with a drop pipe inside the return line. Leaves which had fallen into the aeration tanks and the final settling tank frequently clogged the air line enough to practically shut off the flow of sludge.

This condition was remedied by taking the drop pipe out of the sludge line and applying the air to the elbow on the sludge line where it changes from a horizontal to a vertical position.

* Operator in Charge, Sewage Treatment Plant, Yosemite National Park, California.

Digestion-Tank Drains—A 3-in. drain line with five openings at 18-in. intervals was installed along one wall of three digestion tanks. The drains are reduced to 2 in. near the bottom and have 2-in. valves at the bottom. This method of removing liquids from the digestion tanks is good, as we often find that we are able to drain between the sludge layers. One improvement could be made, however, and that is to increase to 4 in. the size of each drain, as clogging often occurs. We find that matches are a frequent cause of clogging at the point where the 3-in. line is reduced to 2 in.

Disposal of Activated Sludge—Our usual method of disposing of activated sludge is to mix it with raw sludge in the thickening tank and then pump the mixture into one of the digestion tanks. This method has proven satisfactory, except during the summer months when some difficulties have been experienced. Then the production of sludge increases to such an extent that its disposal is a problem.

This increase of activated sludge occurred suddenly and immediately followed periods when it was not possible to have a continuous air supply for the aeration tanks. During the months of May, this year and a year ago, the blowers were out of operation about 2 hr. each day due to power trouble. The dissolved oxygen in the aeration tanks decreased considerably and a light, fluffy sludge resulted. However, the process of nitrification, as indicated by the nitrite nitrogen content, was as complete during this period as usual. We have no record of the amount of activated sludge that was produced, but we do know that the volume wasted was much greater, considering the flow, than textbooks give as the volume to be expected.

During July 1932 we were temporarily unable to dispose of the sludge fast enough to keep up with its production and frequently the sludge blanket in No. 1 clarifier raised enough to allow sludge to enter No. 2 clarifier, which we use as a chlorine detention tank. At such time the continuous addition of sufficient chlorine to maintain a proper residual was difficult because of the varying amounts of organic matter entering the tank. The most serious trouble experienced, however, was with the digestion process. The addition of such large quantities of activated sludge to the digestion tanks seriously inhibited the process and it was often necessary to remove sludge from the tanks before it was fully digested.

This summer we were able to avoid the passage of large amounts of sludge into No. 2 clarifier and this resulted in a considerable saving of chlorine. We pumped the activated sludge back through the primary sedimentation tank and found that this resulted in a more concentrated sludge. As much as possible of the sludge in the digestion tanks was drained to the drying beds early in the summer in order to have available sufficient digestion space for the activated sludge. Nevertheless, the digestion process was again upset this summer.

Next summer it is our intention to try a chemical coagulant such as ferric chloride and find out if we can further decrease the volume

of activated sludge added to the digestion tanks. In the past, 0.2% suspended matter has been maintained in the aeration tanks. No particular harm results to the nitrification process, however, if the suspended matter is reduced to about 0.1%. We believe that it will be possible to avoid disposing of large quantities of sludge by entering the peak-flow season next year with low suspended solid content in the aeration tanks and allowing it to gradually increase. By the time the suspended matter has increased to a critical point we think that the peak of the summer flow will be past.

Disinfection—From bacteriological tests we have found that it is necessary to maintain a chlorine residual of at least 2.0 p.p.m. in order that the plant effluent may be reasonably free from the coli-aerogenes group. So far we can offer no explanation for this interesting condition. From January 1 to August 12 of this year 414 portions (10-c.c.) of the final effluent (three samples collected weekly) were tested for the presence of the coli-aerogenes group at the Federal laboratory in San Francisco. Of this number, 3.8% indicated the presence of the group.

General Results—From January through August 1933, the average suspended matter content of the raw sewage was 91.0 p.p.m. and of the final effluent, 9.9 p.p.m. This is a percentage reduction of 89.2. The average B.O.D. of the effluent of No. 1 clarifier for the same period of time was 4.7 p.p.m.

OPERATORS' EXPERIENCES

By S. M. BENNETT*

It is unfortunate that operators, who have enough to do to adjust plant facilities to produce best results at low cost, have to spend so much time overcoming errors made in the design and construction. In visiting other treatment plants one finds a universal disregard for many details such as location and depth of inlet baffles, proper length of outlet weirs, location of pumps, removal of moisture from digestor gas, failure to provide for reserve aeration capacity, lack of flexibility in the use of pumps, failure to permit various parts of the treatment plant to be interchanged with others, inconvenient location of valves, and improper mechanical setups. I have seen centrifugal pumps for activated sludge clog up and require considerable time to free, where a simple connection with an idle diaphragm pump would have corrected the trouble in a minute's time. I have seen operators attempt to start up pumps, compressors, and speed reducers, only to have them balk or fail because of improper packing, poor alignment of shafts, unbalanced position of pulleys, bearings installed backwards, and other mechanical difficulties caused by improper in-

* Chief Operator, Headworks Experimental Plant, Los Angeles.

spection and installation. Frequently one finds sludge pumps so designed so that the operator has not the slightest idea of what he is pumping. All of these features should be anticipated during the design and construction periods to free the operator from subsequent worry and waste of time.

A sewage treatment plant operator should not have to cope with ordinary annoyances and should be free to devote his time to making adjustments and improvements in the operation of his plant which will reflect directly in reduced costs of operation. Many of the supposed operating difficulties previously regarded as detrimental to the plant not only fade away when proper attention is given to them, but may even be used to the advantage of the plant. One must learn his 'sewage' and be able to identify different types of waste entering the plant. Further, he needs to have at his disposal a liberal supply of lime, ferric chloride, alum, copper sulphate, and chlorine with which he can experiment, first in the laboratory and then on a larger scale, to effect a proper cure for each type of waste as it arrives at the plant. By remembering previous experience with similar waste, an operator can prevent bulking of sludge from such wastes as hominy and peaches, prevent the plant from being upset with pickle waste, and overcome other types of waste entering the plant.

DISCUSSION

W. A. Allen described improvement in aeration results at Pasadena by using transverse baffles in the aeration tanks, eliminating short-circuiting and bulking and reducing plate-area ratio from 1-6 to 1-10 without decrease in aerating efficiency. In the past the use of lime had not corrected bulking at Pasadena. Goudey remarked that aeration tank troubles could be improved by adding lime or other chemical, following with a rest period and settling with the air cut off. Tennant had been able to skim and burn up to 40-bbl. doses of oil at the Los Angeles County Sanitation Districts' activated sludge plant. Lime was not economical in correcting his aeration tank troubles. Diffuser plates were successfully cleaned by water pressure. Safety features were found very much worth while, as was also the employment of operators who were skilled in different trades. Haseltine had used lime successfully at the aeration tank inlet.

A. C. Beyer reviewed operation of the Morristown activated sludge plant, where chlorine is added to incoming sewage when there are signs of septic conditions, thus maintaining proper aerobic conditions in the aeration tanks. Similar results are secured by continuous pre-chlorination on the Los Angeles County Sanitation Districts outfalls. At Princeton the addition of chlorine to sludge digestion tanks to supernatant liquor served to eliminate hydrogen sulphide in the air above the liquid and allowed the supernatant to be fed back into the incoming sewage. Chlorine in the Phoenix thickening tank receiving mixed primary and activated sludge eliminates hydrogen sulphide odors and makes it possible to concentrate sludge before pumping to the digester.

A. E. Gilkey and Kennedy mentioned excessive sphaerotilus growths at some plants. C. G. Hyde reviewed his investigations at Westboro, proving that the combination of soft water and dilute sewage was favorable to sphaerotilus development, particularly in winter—which checked Kennedy's experience. Liquid chlorine or hypochlorite were suggested as a proper means of control.

THE NATIONAL RECOVERY ACT AND ITS RELATION TO THE CALIFORNIA SEWER REVENUE BOND ACT

By C. C. KENNEDY

Like every other group in organized society, the engineering profession has had its basic economic concepts wiped out in the upheaval of the past 2 years. This is particularly true of city engineers and those employed by public agencies.

In former times, the city engineers planned a program of construction and maintenance that would give to the citizens the projects and the service absolutely necessary for the health, comfort, and efficient functioning of community life. Every labor-saving mechanical development or operation was employed to the end that all of the requisite services should be provided at a minimum cost to the taxpayer.

In the period following the collapse of 1929, the whole process has been reversed. Public agencies provided the only source of employment to the millions of workers whom industry could no longer keep profitably employed. The efficient, skilled public employee in whom we had tried to install a pride in his work through fixed tenure of his job when industry was out-bidding the city for his services, became suddenly a political foot-ball. He became the object of bitter attack by the various associations of taxpayers on the one hand, while on the other, an effort was made to multiply (or divide) his job by 10, in order to provide for the discarded workers of the broken-down industrial machine. As a result of this hysteria, work of every description, paid for out of the funds normally available for the orderly expansion and maintenance of public works, has been proposed and undertaken. The type of the project and its value to the community were lost sight of in the rush to get men at work at something.

While this reaction was excusable under the distressing conditions of poverty that developed, the time has come for us to take a sane view of the situation and to attempt to work out the problems of unemployment without the useless expenditure of human effort and the imposition of a debt upon a succeeding generation without some commensurate contribution to its welfare.

The value of a well-conceived program of public works in an established, developed community in maintaining a proper balance between production and consumption has long been known. From the onset of the present depression, outstanding economists and engineers have urged that such a program, continuing over a period of years, if not indefinitely, be formulated for this country. Such an idea was not, it must be admitted, original with this generation.

* Consulting Sanitary Engineer, San Francisco.

More than a century ago, the Emperor Napoleon confronted with a similar situation summoned his Minister of Home Affairs and announced: "I want to do something useful and great for the city. What do you suggest?" "Provide the city with a good water supply, Sire", was the answer of the minister, who expounded a plan whereby the Ourcq water could be conveyed to Paris. "Your proposal is good. Summon G——; he must send five hundred men to La Vilette to-morrow, in order to start work on the canal". Thus could an emperor inaugurate a public works program. For a republic with the complicated financial structures of the twentieth century it is not so easily accomplished.

The first congressional appropriation for a national public works program for $500,000,000 was incorporated in the Emergency Relief and Construction Act of 1932 and placed under the administration of the Reconstruction Finance Corp. Under the provisions of this act, loans were authorized to cities, states, and other local governmental bodies, and to private corporations as well, for construction of public works, the cost of which together with the interest on the loan could be met by revenues. Water systems, power plants, and similar revenue-producing works of cities, where non-competitive with already existing works, came within the scope of the act. In a few of the states, most progressive in public health work, statutes had been passed which provided that the cost of sewage works might be met out of revenues derived from charges imposed on the users of the sewage facilities provided.

The Reconstruction Finance Corp. ruled that sewage works were eligible for the allocation of funds in those states which provided that the cost of the works could be met from revenues. This ruling stimulated interest in providing the necessary statutory authority in other states, that advantage might be taken of a low interest bearing, long-term loan for necessary projects. As a result some twenty states have now passed such laws, most of them during the past year. California was one of these.

The Sewer Revenue Bond Act of 1933, passed and approved as an urgency measure, May 15, 1933, provides in brief that authority rests with the city council or other governing body of a public agency, to pass a resolution of intention, giving notice of its intention to construct sewage works in accordance with plans already prepared, and issue revenue bonds for this purpose. This resolution in the absence of a majority protest or the invoking of the referendum gives full authority, after proper hearing, to the city council to issue and sell the revenue bonds to the Reconstruction Finance Corp. or other governmental agency. The bonds issued thereunder are payable only from revenues derived from the charges made against the users of the works constructed. The responsibility rests on the city council to set up an adequate system of charges to meet: (a) the operating cost of the works, (b) the interest on the bonds, and (c) the sinking funds for the bonds. The provisions of this act are discussed in detail in

a paper prepared for the Engineers and Street Superintendents' Section of the League of Municipalities by W. T. Knowlton. I will not, therefore, enter into a discussion of procedure under the act.

Almost coincident with the passage and approval of the Sewer Revenue Bond Act, the National Industrial Recovery Act was passed and approved by the President, on June 16, 1933. Under Title III of the act, the authority of the Reconstruction Finance Corp. to administer the Emergency Relief and Construction Act was terminated. It is significant to note, that of the $500,000,000 authority granted under the original act, $400,000,000 was turned back to the federal government for distribution under the new act. I am not aware that any grant was actually made for sewer construction under the act of 1932.

Under Title II of the National Industrial Recovery Act are set out the provisions governing public works and construction projects, wherein is created the Federal Emergency Administration of Public Works, shortly abbreviated to PWA, under an administrator representing the President. The appropriation authorized for all projects under this title, totals $3,300,000,000. After deducting the amounts set aside for federal projects, such as highways, harbors, battleships, etc., a balance of $1,300,000,000 remains for allocation to local governmental units for projects local in character. If the unexpended authorization of $400,000,000 in the Emergency Relief and Construction Act is deducted, a net new appropriation of $900,000,000 is authorized for such purposes. In the application of the appropriation, two radical changes from the provisions of the earlier act are incorporated in the new act. The first eliminates the self-liquidating feature as an absolute prerequisite to the granting of a loan, although, by specific reference to the types of project, eligible under the Emergency Relief and Construction Act for loans under the new act, it seems clear that self-liquidating projects will have precedence. The second, and of even greater importance, gives authority to the PWA to make outright grants to the municipality or other public agency in any amount, deemed proper, not exceeding 30% of the labor and material cost of the project.

Subsequent to the passage of the new act, the President named Secretary of the Interior Ickes as PWA administrator. Under the secretary, twelve regional advisors were named with an advisory board in each state. The executive officer of the advisory board is the state engineer (PWA), appointed by and responsible to the administrator. Appointments of the state engineers under the act were not made until August 14, and since that time all details of office personnel and procedure have had to be developed. Circular No. 1 (PWA) outlines the purposes, policies, functioning, and organization of the administration. In it are set out the various types of public works that may be preferred and the order of precedence is given as follows: (1) Water works and sewers, (2) Sewage disposal (when regenerative in character). In this circular, also, the interest of the bonds is set uniform for all projects at 4%, while the bond

amortization is varied according to the life of the project "not to exceed 30 years except in the case of such projects as obviously have a longer life, and in no case to exceed 50 years".

Circular No. 2 (PWA) furnishes an outline of the information required with applications for loans. It provides that complete engineering, financial, and legal information concerning both the applicant municipality and the project be submitted so that the administrator's office in Washington may pass upon the projects from every angle.

It is too early to determine with what ease and to what extent, the funds made available to the Public Works Administration will be allocated to sewage works construction. A precedent has been established for the purchase of revenue bonds for water system construction. There can be no doubt the Sewer Revenue Bond Act gives authority for the issue of bonds that meet both the express and implied conditions of the National Recovery Act. It is the type of work which would head the list in any comprehensive, constructive public works program. Finally, the maximum grant of 30% of the cost of labor and materials is made available only for waterworks and sewage works construction.

It therefore seems fair to conclude that the attitude of the PWA is distinctly favorable toward the aid of needed sewage works and that such favorable conditions for the construction of such works will not always continue nor soon come again.

THE USE OF ASSEMBLY BILL NO. 980 WITH REFERENCE TO SEWER SERVICE

By W. T. KNOWLTON*

At the last session of the State Legislature a bill was introduced in the Assembly which provided for the cost of construction and operation of sewerage systems and treatment plants from sale of revenue bonds to the Reconstruction Finance Corp. or other fiscal agency of the United States, and also provided for establishment and collection of service rates to pay such costs, which would in turn pay for the bonds.

This Assembly Bill, numbered 980, was introduced January 25, 1933, and amended several times in both Assembly and Senate before it passed the Legislature and was signed by the governor. In Sec. 18 of the bill it is specified that this act shall be known as the 'Sewer Revenue Bond Act', and may be so referred to in all proceedings relating thereto.

Owing to the fact that unemployment has produced an alarming economic condition in this state and that many cities and counties may be enabled to finance the construction of sewer systems and treatment works, which otherwise could not be financed at this time, thus furnishing employment to many now out of work, this act was declared to be an urgency measure necessary for the immediate preservation of the public peace, health, and safety, and accordingly was to go into effect immediately.

Sec. 1 of this act states that all cities, counties, sanitary districts, and sanitation districts are authorized to acquire, construct, and operate sewage treatment

* Sanitary Engineer, Los Angeles Bureau of Engineering.

plants, sewers, pumping plants, and other necessary appurtenances and also to issue and sell revenue bonds to the Reconstruction Finance Corp. or other fiscal agency of the United States. In this act the term 'works' is construed to mean such structures and property necessary therefor.

Sec. 2 places the acquisition, construction, and operation of such works and the collection of charges for the use thereof under the supervision and control of the governing body of the city, county, or district.

In Sec. 3 the governing body is given power to take all measures and make all necessary contracts, employ engineers, architects, inspectors, superintendents, managers, collectors, and attorneys required to carry out said work. All compensation and expenses incurred in carrying out this act is to be paid solely from funds provided by the act. After acquisition or construction of the works, the governing body shall supervise and control their operation, unless such authority is delegated by the governing body to an administrative board or commission which shall establish rules and regulations for the proper maintenance and operation thereof.

Sec. 4 states that all necessary preliminary expenses incurred by the governing body, including surveys, plans, and estimates of costs and revenues, compensation of employees and taking of options paid prior to the issuing and sale of revenue bonds, may be advanced out of the general fund of the city, county, or district, with the understanding that this general fund shall be fully reimbursed out of the first money received from the sale of bonds.

Sec. 5 states that prior to the construction of sewers or plants under this act, the governing body shall adopt a resolution in which there is given the following:

(a) A general description of the proposed work with reference to plans and specifications that shall have been made and filed by the engineer selected by the governing body.

(b) The estimated cost of the work and revenue bonds to be issued and sold therefor.

(c) A general description of the district to be served, with reference to a map thereof.

(d) An estimate of the number and character of places and properties to be served, including those ready for immediate service and those expected in the future.

(e) An estimate of the immediate revenue to be received, and also future revenues.

(f) A statement that the revenue bonds will be issued to cover the cost of the works and sold to the Reconstruction Finance Corp. or other fiscal agency of the United States.

(g) A notice of the time and place for any protestants to appear before the governing body, which time is not less than 20 days nor more than 40 days after adoption of the resolution.

Sec. 6 contains details of the notice to be given to the public and hearings to be held. If written protests are filed, which are signed by more than one-half of the owners of improved real property in the district to be served, no further action can be taken for six months, and then only on passage of a new resolution.

If 15% or more of such owners file a request to hold an election, the governing body shall then call for an election which, however, is restricted to such owners. Individuals, companies, or corporations have but one vote regardless of the amount of land which they may own. In case no protest is filed and no election is held, the governing body can then proceed to file a request with the Reconstruction Finance Corp. or other fiscal agency of the United States to purchase revenue bonds.

Sec. 7 states that in the operation of the work to be done, each city, county, or district has the right to sell the sewage effluent, fertilizer, or other by-products of the sewage treatment, and to construct and maintain conduits for distribution of such effluent.

Sec. 8 states that the governing body shall have power to establish just and equitable rates or charges for the use and maintenance of the proposed sewer system and plants, to be paid by the person or company leasing or occupying the

building or premises served, and may change or readjust these rates or charges from time to time. These charges shall be sufficient yearly to pay for the cost of operation and maintenance of the works, also for sinking fund charges.

This section also contains details of methods for establishing the charges.

All such charges if not paid when due shall constitute a lien on the premises served. If such charges are not paid within 30 days after becoming due, the amount with a 10% penalty may be recovered by civil action. The governing body may fix variable charges for different classes of users or for different parts of the city where sewage works have been installed and financed under other laws, provided that such charges are equitable and just and that the property so charged is served by works built with money derived from the sale of such bonds. Should users of works built and financed by other funds, receive additional benefits from works built from the sale of revenue bonds, then the governing body may charge to cover the value of such additional benefits.

Sec. 9 covers the details of establishing charges sufficient to meet interest and principal on outstanding revenue bonds in addition to the cost of operation, also details for banking all moneys collected.

Sec. 10 provides that when any portion of the city, county, or district is provided with sewers, the governing body shall require all inhabited buildings to be connected to such sewers within 90 days after completion, provided that such buildings are not over 100 ft. from the sewers.

Sec. 11 specifies that the revenue bonds shall be paid within a period not exceeding 40 years from their date and shall bear interest at a rate not exceeding 6% per year. This section also gives details in regard to the issuing of bonds and yearly payments thereof.

Sec. 12 states that after reimbursing the city, county, or district for all amounts advanced for preliminary expenses, all moneys received from the sale of bonds (other than that for premium and interest) shall be applied to cost of work to be built under such bonds.

Sec. 13 gives details for the creation of a sinking fund.

Sec. 14 provides for the proper accounting and auditing of all funds.

Sec. 15 permits any city, county, or district owning or operating such sewage disposal works to contract with other cities, counties, or districts (called lessee) for the use of such works, provided that no contract shall exceed 15 years. This section also gives details of how the lessee may fix and collect charges within its boundary and as to the amount which the owner may charge the lessee.

Sec. 16 provides that when the Reconstruction Finance Corp. purchases the revenue bonds, it may require that the governing body shall use day-labor in doing the work instead of by contract. This section gives details of requirements calling for proposals for the work and the awarding of contracts.

DISCUSSION BY ROBERT LINTON*

Knowlton gives an excellent presentation of the provisions incorporated in this measure which is known as the 'Sewer Revenue Bond Act'. As Knowlton states, the necessity for enacting such legislation arose from the situation prevailing in most cities and districts which made it impossible to finance new construction of sewer systems and their appurtenances under existing laws. Under the previously existing laws, funds are provided either through assessments against properties served or benefited, or by issuing bonds for the approval of which a two-thirds vote is necessary. During the period of rapid civic development in many sections the privileges of these acts have been used to excess, the result of which has been a strong reaction against further sewer building, and in consequence some sewers that are badly needed could not be provided.

The purpose of the Sewer Revenue Bond Act was to provide a means of building such sewers in municipalities or districts where the residents want them badly enough to pay directly for the service. The legislators were very careful to embody in the act all possible safeguards against the measure being used for speculative purposes and limited the disposal of the bonds to the Reconstruction

* Vice-president and general manager, Pacific Clay Products, Los Angeles.

Finance Corp. or other fiscal agency of the United States, further providing, however, that nothing contained in the act shall be deemed to prohibit such fiscal agency of the United States from reselling or otherwise disposing of any of the bonds it may purchase under the act. Consequently, in financing a sewer system by means of this act not only must all of the conditions embodied in the act be observed, but also all of the requirements set up by the Reconstruction Finance Corp. or the governmental organization charged with administering Title II of the National Industrial Recovery Act.

It is therefore not easy to apply the act, but entirely possible to make use of it for projects which can comply with the requirements. Any municipality or district desiring to do this should first analyze the project to determine (1) whether it is a project which is needed at the present time or whether its construction could be deferred without serious detriment to the people proposed to be served, and (2) whether the district will supply the necessary revenue over the period of the bonds so that interest and sinking-fund requirements shall be met.

With our present serious unemployment situation the question of immediate necessity may be considered of less importance in view of the fact that new sewer construction will give employment not only to the force employed in laying the sewer but to employees of the manufacturing establishments that furnish the materials. Since in applying Title II of the National Industrial Recovery Act the federal government appropriates in certain cases 30% as a direct contribution to employ men on needed public works, it may be possible for sewer districts to proceed under the Sewer Revenue Bond Act and by securing this appropriation of 30% to build a sewer system by issuing revenue bonds for 70% of the cost. In other words, if the district will show an unquestioned earning ability to provide the interest and sinking fund on bonds representing 70% of the cost, the act might be applied by some municipalities or districts which otherwise could not use it.

The bill is an enabling act, and therefore any municipality or sewer district desiring to make use of its powers must enact suitable ordinances. The act does not specify any particular means of assessing the charges. In municipalities which now make charge for sewer services the practice varies widely. The majority apparently base it on the water consumption of the premises served, but others base it on the number and type of plumbing fixtures, number of persons served, size of the building or number of rooms served, and others base it on a flat rate per month.

The practice of making charges for sewer service is not new. Massachusetts passed a law providing for such charges over 40 years ago. A study of existing sewer rental laws and charges was made for the Metropolitan Drainage Commission of Minneapolis and St. Paul, the results of which were published in the November sisue of the 'Sewage Works Journal'. These studies showed that 26 states and the District of Columbia had legalized the practice of making charges for sewer service and that (in 1931) 328 municipalities had enacted local ordinances providing for service charges. These laws in some cases provide for complete payment of all items including maintenance, operation, and repair, together with interest and retirement of bonds for construction of sewerage systems, while others provide only for operation, maintenance, and repair. Details such as these are wisely left to each community to determine for itself.

It would therefore seem that the California Legislature in passing this bill took a progressive step. The repeal of a number of street improvement acts which had become obsolete or whose provisions lent themselves to abuse clarified, simplified, and improved the statutory provisions in California for all street improvement work including sewer construction, but in so doing the difficulty of financing new sewer work has been increased. Legalizing the application of the principle of paying for the sewer by funds realized from charges for its use should prove to be a proper and helpful addition to these laws. Such legislation should have a permanent place in our California statutes and it is to be hoped that the next Legislature will remove the restriction on the disposition of the revenue bonds so that they can be issued not only to fiscal agencies of the United States but to investors in bonds to whom such a security might appeal.

HAZARDOUS GASES IN SEWER MANHOLES*

By C. H. FRY†

The U. S. Bureau of Mines has made investigations of the gases found in manholes and has indicated various ways of detecting them.

In order that manholes may be safe for workmen and that there shall be no explosions or fires, it is necessary that these gases, insofar as possible, be kept out of the sewers and that no volatile liquids which might cause trouble be permitted to enter the sewers. Traps have been devised to prevent light, volatile liquids from entering the sewers, but these traps are not entirely satisfactory.

It should be assumed that every manhole is dangerous and, therefore, must be properly ventilated. It may be possible by opening several manholes to get a draft from one to another, replacing the atmosphere within the sewer by fresh air. After this has been done, however, tests should be made to determine that the results desired have been secured and that no dangerous gases remain. Mechanical ventilation will be required at times and a simple, portable apparatus is now available.

Reference has been made to a number of publications by the U. S. Bureau of Mines. I would suggest that in addition you refer to the National Safety News of March 1932, published by the National Safety Council, and to the quarterlies of the National Fire Protection Association, particularly Vol. 23, No. 4; Vol. 25, No. 1, and Vol. 46, No. 1. There is also an article in the 1930 Transactions of the National Safety Council on this subject.

These various articles go into detail regarding past explosions and fires in manholes, giving the results of the damage and the loss of life and personal injury. Two sanitary engineers lost their lives in a sludge-sampling manhole in Lima, Ohio; and the articles referred to describe explosions and fires in London; Boston, Massachusetts; Newburgh, New York; Baltimore, Maryland; Minneapolis, Minnesota; Ottawa, Ontario; and other localities.

The atmosphere in a sewer—and it is well to repeat this—should be considered to be hazardous until proved otherwise. Whether these gases are the result of chemical action within the sewer, liberation of volatile gas from liquid, or the leakage of gas from foreign sources, is immaterial. In cases where it is necessary to work in the presence of these gases, there seems to be no satisfactory equipment other than the hose-type mask, by means of which a man working in the sewer is supplied with fresh air from the outside, thus breathing fresh air at all times and none of the atmosphere within the sewer.

Unfortunately, since the World War many people—and particularly the returned soldiers—have an erroneous idea of the value of the so-called army gas masks or the all-service gas masks. These gas masks and other masks are designed to be used under special conditions, for certain gases or mixtures of gases, for certain concentrations and for limited periods of time, and they should never be used under any conditions other than those for which they were designed. Many lives have been lost because someone thought a gas mask was good for a certain condition, whereas it was not. No gas mask will furnish oxygen. If there is a deficiency of oxygen the oxygen-breathing apparatus can be used, although it was designed for another purpose and there might be constituents in the sewer atmosphere that would go through the oxygen-breathing apparatus and perhaps cause death to the wearer. A hose-type mask should be used.

No man should go into a manhole until it is shown to be safe, and he should always have someone on the outside. If there is any reason to believe that dangerous gases are present, he should wear a life belt and line so that in emergency he might be taken out. In Milwaukee, in 1922, a laborer went into a sewer and did not return; the second laborer went in to investigate and he failed to

* Paper presented at Spring Conference of California Sewage Works Association, San Luis Obispo, May 5, 1933.

† Superintendent of Safety, State Industrial Accident Commission, Sacramento, California.

return; the Fire Department was called and three firemen went into the sewer, and none of them returned. Finally, a rescue squad, wearing gas helmets, went after the men and brought them to the surface—all dead.

The use of blow torches, charcoal stoves, furnaces, or open flames of any sort should be strictly prohibited in manholes or in sewers.

Where the manhole may become covered with ice, snow or dirt, ventilation will be retarded if not completely stopped, and there may be an accumulation of gas which would not have occurred under normal conditions.

Although the flame safety lamp has been used for testing the atmosphere in sewers and in manholes, it hardly seems possible that the lamp is suitable for this purpose. To be used successfully the lamp must be close to the observer and he must be able to look directly at the flame in the lamp. The changes in the flame at the lower percentages of combustible gas are not readliy discernible by many individuals and, therefore, cannot be depended upon. As the lamp itself must be in first-class order and must be filled, trimmed, repaired and assembled by someone particularly qualified to do that work, the lamp when called in actual service is likely to be out of order and perhaps unsafe. There is a report, unverified however, that one of these lamps was not in proper condition and its use caused an explosion, resulting in the blowing up of four manholes and damaging a Ford automobile which was parked over one of the manhole covers.

If a man is burned by an explosion within a manhole he should be treated the same as for any burn. If he is overcome by gas he should be immediately taken to fresh air and given artificial respiration by the Schaefer prone-pressure method. It is not necessary to describe that method of resuscitation, as you all are or should be familiar with it. If you are not I hope that you will make it your business to learn it, without delay. Every Boy Scout knows the method, and it is taught by both the U. S. Bureau of Mines and the American Red Cross. In California the saving of many lives has been attributed to this method of resuscitation.

There are on the market at this time a number of devices which are recommended to be used in connection with artificial respiration. The U. S. Bureau of Mines and many other organizations are on record as opposing any form of mechanical resuscitation. There should be a distinct understanding as to the difference between mechanical resuscitation and manual resuscitation, either with or without an inhalator. An inhalator is merely a device by which oxygen, perhaps with a certain per cent of carbon dioxide, is given to the patient during manual artificial respiration and is without any value, unless it is so used. A mechanical resuscitating device is a device that forces air into and takes it out of the lungs, and the use of this sort of a device should not be permitted, although many of them are now in the hands of the various fire departments and even in some hospitals throughout the United States. No recognized authority has approved of their use.

It is essential in setting up any definite instructions for testing manholes and for procedure to be used before and at the time of entering the manholes, to make a study of the problem, of the loss of life, and the enormous property damage that has occurred from sewer explosions, and of the cause of these explosions. Fortunately, these explosions do not occur every day, nor do they occur frequently in the experience of most of the men doing this type of work. Consequently, it is difficult to convince these men of the necessity for proper testing and proper working provisions, until a serious accident occurs. Then precautions are taken for the time being.

Some of the public utilities, such as the telephone and telegraph, gas and electric companies, have set up very complete instructions which must be followed. The Pacific Gas & Electric Co. issues definite instructions governing the procedure to be followed in detecting gas leaks and before entering or working in manholes or vaults. Similar instructions are issued by other companies. Those who are in charge of sanitary districts, sewage districts, and similar work should realize the hazard and should not only make a thorough study of the problem which is theirs, but should apply that study to their own particular requirement. Asphyxi-

ating, explosive, and poisonous gases are commonly found in sewers, perhaps not frequently in dangerous quantities. However, may I repeat again that the presumption should be that it is unsafe to enter a sewer or manhole until it has been found safe.

On January 19, 1933, your association wrote the State Industrial Accident Commission, enclosing a copy of a resolution concerning hazards in sewers, and suggesting that the Industrial Accident Commission assist in preparing a safety code for use in sewers and storm drains and in sewage disposal work. The commission will be glad to cooperate with your committee at any time convenient to you. The problem is not one that can be satisfactorily handled in a few minutes' deliberation, and an investigation should be made of the practices in other sections of the United States and of the world, and the best of those should be put into the form of explicit orders. All industries having to work in manholes, vaults, and underground conduits or sewers, and in sewage disposal plants should be asked to collaborate in this work.

KEEPING POWER BILLS DOWN—ELECTRICALLY*

By EARL E. THOMAS†

Economy of operation is just as essential for sewage treatment plants as for factories, although no profits are dependent upon it, but economy cannot be acquired at the expense of reliability and continuity of operation.

The solutions of the problem can be classified under two headings—(1) improvement and correction of existing systems, and (2) application of good engineering methods to new installations.

Improvement of Existing Systems—Our mechanical age has progressed so rapidly that there have been many improvements in equipment and methods, some of which can be applied to existing installations (a) without any particular cost, others (b) with slight costs, and some (c) with considerable cost, but with rapid or ultimate savings sufficient to pay for themselves as good sound investments.

(*a*) *Correction with no Cost*—Owing to error in original selection or to subsequent changes in load conditions, motors are found not to be operating under proper load conditions.

In a group of 20 motors, probably five to eight are very much overloaded, ten to twelve reasonably well-loaded, and two to four seriously overloaded.

Modern motors are most efficient at full load, with good efficiency at three-quarters load, only fair at half-load and very poor at one-quarter load; a good average being:

Load	¼	½	¾	1	1½	
% Eff.	78	88	90	91	90	Modern motors
% Eff.	65	78	83	85	86	Very old motors

Sometimes by interchanging motors to improve the loading conditions the increased efficiency will produce a definite saving in the power bill. It is also evident that the substitution of a new motor for an old one might pay for itself by the increased efficiency, and where it is impractical to regroup the motors, power can be saved by keeping the less efficient machines for standby or peak-load service.

Tests show that transformers are often underloaded, due to the failure of the load to increase as much as was expected. If smaller units cannot be substituted, one of the three single-phase transformers can be disconnected and the system operated in open delta. Transformer losses are small compared to motor

* Abstract by H. K. Palmer of article published in October issue of 'General Electric Review'. Paper read at San Luis Obispo Spring Conference, C.S.W.A., 1933.

† General Electric Co., Los Angeles.

losses, but the motor losses are effective only when the motor is running, while the transformer losses are always there 24 hours per day and 365 days per year, or so long as the transformer is connected to the line.

The utility or public service companies usually provide good voltage regulation, but if the plant is on the end of a long feeder line carrying large variable loads, there may be large fluctuations. If it is constantly too high or too low, it can be remedied by changing to another transformer tap; but if there are severe swings in the voltage, the wires may be too small, or an induction voltage regulator may be required. Severe voltage fluctuation of 25 to 35% may be damaging to the plant equipment, is detrimental to the most economical operation, and will often allow various machines to drop out of step or stop on a voltage drop. Operation at over-voltage causes excessive excitation or core losses, and low voltage causes excessive current to flow in order to do the same work, making high copper losses. Low voltage also allows induction motors to slow down. Continuous operation under either condition is inefficient, and in many cases dangerous.

Most power companies give a rebate for good motor factor or impose a penalty for poor power factor. The rebate may amount to 10 or 12% of the monthly bills. Power factor can be improved by using synchronous motors, capacitors, or by the elimination of motors having poor power factor. The comparative figures on power factor of the modern and old motors look even worse for the veteran than the efficiency figures previously cited.

Improvement in Power Lines—With the gradual growth of a plant, more load may have been put upon the interior distribution lines than was anticipated when they were first installed, and copper losses may be excessive. Many of the overload relays intended to protect motors are found not to be properly set, and perhaps only 10% of the old oil-dash pot type of overload relays are operative. Often fuses are bridged by wire instead of being re-fused. Exposed copper tends to discolor and corrode rapidly around a sewage plant. Most disconnect switches have tarnished copper surfaces and will be found to be hot at the joints. This is a direct indication of the electrical losses, and hot wires indicate inadequate sizes of wiring and excess power loss.

Changing to High Voltage—When the plant is small, with small motors, 220 (or even 110) volts is often used. Motors larger than 10 or 15-hp. or plants having a total of more than 50 or 75 hp. should in most cases be 440 volts, except for much larger motors, which should be 2300 volts. All motors in one plant should be of the same voltage except where there are large motors of 200-500 hp. along with small motors of 2, 5, and 10 hp., in which case the large ones should be on 2300 volts and the small ones on 220 or 440. Small motors running grinders, jig-saws, polishers, buffers, etc., are operated off the 110-volt lighting circuit. As this is paid for separately on a high rate, it would be cheaper to change such motors to the power circuit if possible.

Adding Indicating Devices—In many plants the addition of indicating devices such as ammeters, wattmeters, power-factor meters, water-level indicators, etc., will pay for themselves many times per year by allowing the operators to scientifically control their equipment instead of guessing.

Repairs and Re-alignments—It is poor economy to neglect repairs and maintenance work, as worn bearings will cause an eccentric air gap in motors, which in turn causes hot spots and excessive losses, and eventually allows the rotor to rub the stator and cause burnouts. Mis-alignment and poor balance are causes of many breakdowns and delays. Excessive vibration will loosen the motor coils, wedges, etc., and chafe the insulation until the coils eventually are grounded.

Other matters of maintenance such as proper changing of oil and greasing motor bearings, keeping motors free from dust, water and oil, applying insulating varnish at regular intervals, grinding communtators of DC motors and generators, trueing slip rings of induction and synchronous motors, replacing and staggering of brushes, replacing contactor and oil circuit-breaker contacts, checking overload relay settings, testing for grounded coils or defective wiring, and many others have a very direct effect on reducing the power bill and decreasing maintenance costs if properly carried out.

Changes of Appreciable Costs

Substituting Synchronous Motors—For motors of 100-hp. and larger, synchronous motors are to be preferred to induction for the following reasons: better efficiency; better power-factor; power-factor correction; constant speed drives; slow speed drives.

In ratings of 200 to 500 hp. the efficiencies of synchronous motors are from 1 to 3 or even 4% better than induction motors at average speeds, and from 2 to 5% better at slower speeds. If the difference is 3% on a 500-hp. motor running continuously on power at 1c per kw-hr., the saving will amount to 12c per hour or $1050 per year.

Synchronous motors are made to operate at unity or leading power factor, the former being the most efficient, and the latter used to correct lagging power-factor of other induction motors in the same plant. In cases where absolutely constant speed is required and in many cases where speeds as low as 250 to 100 r.p.m. are required, the synchronous motor is an ideal application.

The matter of changing existing induction motor drives to synchronous type is purely a question of economics involving the cost of new equipment, cost of installation and increased return or decreased expense, and capitalization of these figures. For example: if the change cost $3000 total and would save $1500 per year it would pay for itself in 2 years, a 50% investment. After 2 years this change is making a clear return or profit of $1500 per year.

Capacitors or static condensers may be used in place of synchronous motors for correcting low power-factors. Their use may not only earn a rebate on the power bills, but will reduce the current and often obviate changing feeder lines and transformers to large sizes due to overloaded conditions.

Transformers that are too small will cause excessive voltage drop and endanger the life of transformers and motors and the continuity of service. This should be avoided to protect against burnouts, fires, shut-downs, and other severe losses. Transformers either too large or too small involve unnecessarily high losses. A rough rule to follow is 1 kv-a. in transformer capacity for each hp. in operating motors.

Larger Motors—As conditions of operation change, the total duty imposed on pumps, compressors, and other machines may overload the motors and closing the control valve or orifice is very wasteful of power. The correct solution is to change the pump runner and increase the size of motors.

Often automatic control devices such as pressure regulators, water-level controls, etc., will save a waste of power.

Variable-speed drives are of a distinct advantage in many operations in connection with pumping, treatment, and disposal of sewage so as to adjust the speed of different operations to meet varying flows of sewage received. These devices may be driven by slip-ring induction motors using resistance in the secondary for speed variations, or by the less familiar but more efficient brush-shifting AC motors.

Any of the above changes should be made only as a result of accurate tests, taking into account the cost of the changes and the saving to be expected.

The object of this Association shall be the advancement of the fundamental and practical knowledge concerning the nature, collection, treatment and disposal of sewage and industrial wastes, and the design, construction, operation and management of sewage works in California, through the interchange, between members of the association and with others, of information, experience, and opinion relating thereto.

—Article III, Constitution, C.S.W.A.

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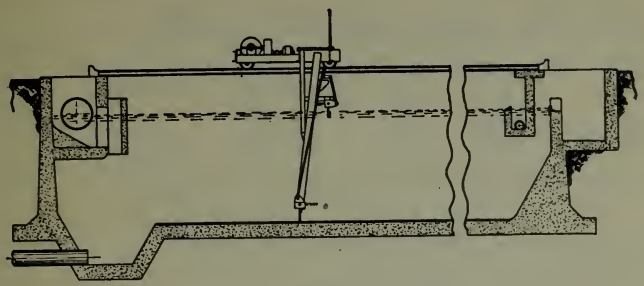
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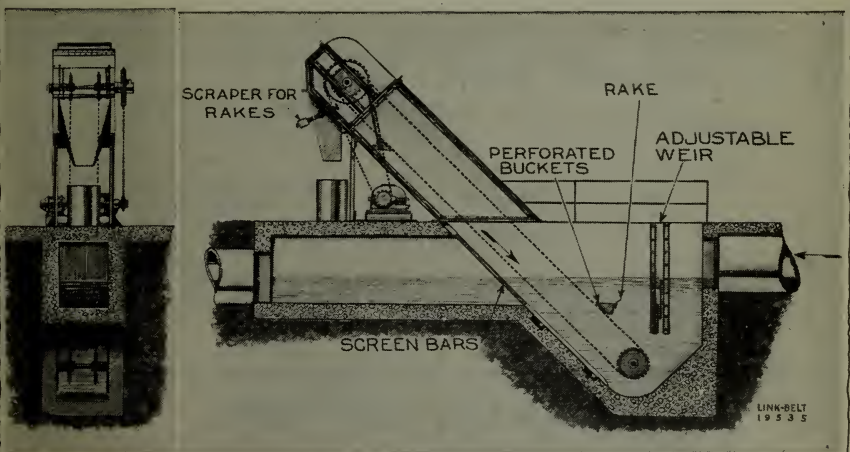
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Official Publication of the California Sewage Works Association

Vol. VI • 1934 • No. 2

Minutes of the
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Program

FRIDAY, MAY 25, 1934

8-10:30 a. m.—Inspect Valley activated sludge plant.

11-12 noon —Inspect Valley camps, incinerator, can-bailing machine, etc.

12:15 p. m. —Luncheon.

2-5 p. m. —Papers and discussions—Assembly Hall, Old Village.
1. 'Handling Flood Waters at a Disposal Plant, with Comments on the Need for Grit Basins', by A. W. Wyman.
2. 'Patented Ideas for Sewage Disposal', by R. F. Goudey.
3. 'Slime Growths in Sewers', by F. E. De Martini.
4. 'Experiences with CWA and PWA in Connection with Sewer Construction', by C. M. Hoskinson, R. R. Ribal, F. D. Bowlus, W. F. Foster, and others.

7 p. m. —Dinner at Camp Curry and presentation of Award of Merit.

SATURDAY, MAY 26, 1934

9-12 noon —Papers and Discussions, Assembly Hall, Old Village.
5. 'Oxidation Potential Theory Applied to Sewage', by R. D. Pomeroy.
6. 'Utilization of Sewage Gas', discussion by J. F. Byxbee and others.

1:30 p. m. —Trip to Wawona tunnel, Wawona, and Mariposa Grove of Big Trees.

6 p. m. —Indoor barbeque at Camp Curry.

SUNDAY, MAY 27, 1934

9:30 a. m. —Trip to Hetch Hetchy sewage disposal plant and O'Shaughnessy dam.

The object of this Association shall be the advancement of the fundamental and practical knowledge concerning the nature, collection, treatment and disposal of sewage and industrial wastes, and the design, construction, operation and management of sewage works in California, through the interchange, between members of the association and with others, of information, experience, and opinion relating thereto.

—Article III, Constitution, C.S.W.A.

WE SEE YOUR HAT

To the Sewage Works Association of the Northwest—Idaho, Oregon and Washington—we of the California Sewage Works Association send greetings, with the wish that you may do the job for which you are organizing thoroughly and well. It is a big job, already demanding attention, and growing rapidly in importance. From experience we can say that you will do well to seriously consider not only the part your new organization is to play in "Keeping the Far West Clean" but also what impressive results may accrue from your independently directed activities.

Nothing assumes greater significance in our modern civilization than the task which brings sewage workers together. Fortunately sewage works associations are democratic institutions. The greatest and the least of those engaged in the job foregather from time to time to exchange "information, experience and opinion" relating to their work. See that all are heard. The advancement of the science and art of sewage collection and disposal depends not only upon the academic knowledge of the men of letters but also upon the practical experience of the untutored. Timely interchange of knowledge will prove of great assistance to all members.

Experience has already taught us in California the value of organization independence. We have every desire to see you keep your objectives clear; unclouded by other issues and uninfluenced by the pressure of politics. Sacrifices of principle to expediency are sacrifices of organization esprit de corps.

There are sewage works associations all over America and in Europe. Just as yours proposes, they likewise include in their membership any who are interested in the direct solution of the vexing problems with which sewage workers are confronted. Doubtless at some time or other the name Sewage Works Association has been challenged upon aesthetic grounds in each of the organizations so described. Unfailingly, however, the word Sewage enters the title as the only one descriptive of the association's activities. There is nothing abhorrent about the word, but much to be feared from the substance which it describes if the sewage worker is not well trained and on the job. The greatest modern sanitarians and stream pollution students in the world are members of sewage works associations. Don't restrict your activities by a pseudonym.

Anyhow, we offer best wishes. To us you are the Northwest Sewage Works Association. We recognize you by your hat in spite of the fact that you are attempting to disguise yourselves behind the Isaak Walton Leaguish whiskers which you describe as the "Northwest Conference on Stream Pollution"—so **come on out.**

A. M. RAWN.

SIXTH ANNUAL C.S.W.A. SPRING CONFERENCE AT YOSEMITE, MAY 25-26, 1934

By E. A. REINKE*

Morning Session, May 25, 1934

Members and guests of the California Sewage Works Association assembled at the Camp Curry headquarters at 8 a.m. and proceeded in small groups to the activated sludge sewage treatment plant on the south side of the valley near Bridal Veil falls. Inspection of the plant, laboratory, and records was under the direction of the local arrangements committee, consisting of H. B. Hommon and E. M. Hilton. A caravan was formed at the plant and conducted on a trip through the valley, stopping at a CCC camp, visiting automobile and housekeeping camps, and inspecting the incinerator, can-bailing machine, and equipment for washing garbage cans.

Informal groups met together at lunch.

Afternoon Session, May 25, 1934

The meeting was called to order by president McMillan who introduced Harry B. Hommon as the man primarily responsible for our meeting in Yosemite. He introduced the park superintendent, Col. C. G. Thomson, who welcomed the association to the valley, and told a few of his experiences in oriental countries, particularly the Philippine Islands, and the constant watchfulness needed to safeguard health in those countries. The work of Harry Hommon and his associates in the Public Health Service is greatly appreciated by the National Park Service.

Proceeding with the regular business, president McMillan first called attention to the fact that A. M. Rawn had arranged for the papers to be presented.

A. W. Wyman read a paper entitled "Handling of Flood Waters at a Disposal Plant, with comments on the need for grit basins". The New Year's storm, the heaviest in 50 years, resulted in an increase of flow from 8 m.g.d. to 25 m.g.d. with complications, including deposit of sand in aerating units, and reduction of nitrogen content in fertilizer. A grit chamber would be a great asset during heavy storm periods. Harold F. Gray in discussion called attention to the economics of storm sewer design, the arbitrary assumption of capacities, and the need for data on storm damage. Such data should, he stated, be available on the storm referred to in Wyman's paper. A. M. Rawn drew attention to the need of definitions, separate sewers being not actually separate when storm flows increase normal sanitary flow

* Secretary-Treasurer, California Sewage Works Association; Senior Sanitary Engineer, Bureau of Sanitary Engineering, State Department of Public Health, Berkeley.

threefold. R. R. Ribal gave experiences in Oakland where storm sewers are overloaded. Col. Smith of Los Angeles reported the practice of cross-connecting storm and sanitary lines when numerous bond issues for relief sewers were turned down. The only alternative is to let lines fill up and sewage run down the streets. Prof. C. G. Hyde suggested discussion, at a future convention, of the whole subject of ventilating manholes. T. F. Eastman and H. B. Hommon also discussed the paper.

R. F. Goudey read a paper entitled "Patented Ideas for Sewage Disposal" in which he brought out the fact that nearly every device used in sewage disposal works is or has been patented. Patents have dominated all other lines of engineering endeavor and must be recognized in the field of sewage disposal. Goudey reviewed the patent situation comprehensively and pointed out the need for engineers and operators to circumvent patents and avoid infringement. Alva J. Smith asked where the engineering profession was drifting. If all devices and improvements are patented, he asked, are sanitary engineers simply to select the patented device they think best to submit to the Council of the city, and will a battle rage between patents before the City Council? A. M. Kivari of the Dorr Co. congratulated Goudey on his presentation of the subject. Kivari explained the status of patents in other commercial and industrial fields and stated that if experts on research are to be hired, the investment must be protected by taking out patents on ideas developed. W. A. Allen suggested that consulting engineers should apply patents to better advantage. C. C. Kennedy emphasized the distinction between Process Patents and Mechanism Patents and said the former involved royalties or percentages and nearly always political conditions which we should try to avoid. He favored mechanism patents to which he thought there could be no objection. G. S. Backus, of Oliver Filter Co., said he thought Kennedy referred to Royalty Patents and Apparatus Patents and referred further to the research necessary to develop a process which could only be protected by a royalty patent. J. F. Smith, of Great Western Electro-Chemical Co., agreed with Kennedy in favoring equipment patent. His company owns many process patents, but where cities take open bids, it is difficult to include royalties in bid prices. He thought there was a justification for royalties but it was almost impossible to collect them.

President McMillan called a short recess.

The next paper read was "Slime Growths in Sewers", by F. E. DeMartini. A general discussion of the more common fungi, including Clodothrix, Sphaerotilus, Leptomitus, and Beggiatoa was given, describing their appearance and growth habits. Occurrence of these organisms at sewage disposal works at Dunsmuir, Roseville, Shastina, Yosemite; Choteau, Montana; Sparks, Nevada; and along Auburn ravine below Lincoln, Linda creek below Roseville, Santa Maria river below Guadalupe, Truckee river below Floriston, Mokelumne river below Lodi, Kings river below Reedley, was described.

Sewage, and wastes containing carbohydrates, including milk plants, peach canneries, wineries, beet sugar plants, were contributing factors. Use of copper sulfate, lime, and hypochlorite solutions has been tried with varying success.

Prof. Hyde in discussion referred to slime trouble at Westborough, Massachusetts, in 1899, and described in considerable detail the effect of paper-mill wastes on Truckee river below Floriston, Sphaerotilus being the predominating organism. C. C. Kennedy also discussed the paper and referred to the high water consumption and dilute sewage, at most of the places reported as having slime growths. At Sparks, Nevada, for example, the b.o.d. was less than 100 p.p.m. and slime growths plentiful, whereas at Reno, Nevada, with the same water source, the sewage was stronger, b.o.d. about 275 p.p.m., and there are no slime growths. R. C. White, of Yosemite, reported growths in the sewer system. Sewage is dilute and cold, with average temperature of 47 to 50° F. Use of chlorine at the head of the system loosened growths and allowed them to be collected at the grit chamber. The most serious effect of the growths is to increase screenings at bar screens. However, their presence does not improve appearance of aeration tanks and final clarifiers. W. T. Knowlton reported similar growths near Los Angeles in ditches containing waste water from moving picture plants, sewage or sulphur ingredients. R. C. Pomeroy asked the meaning of the term carbonaceous. DeMartini answered that he meant chiefly carbohydrates such, for example, as beet-sugar plant wastes.

The next discussion was on the general subject of PWA and CWA projects.

C. M. Hoskinson, of Sacramento, described a successful group of projects under his direction, including grading and refencing, replacing curbs and gutters, investigation of sanitation basins, installation of sprinkling system, refinishing interior of filter house and pumping station, and repainting. No sewer work was undertaken.

R. R. Ribal, of Oakland, gave a detailed discussion of relief work done by that city. His conclusions were that the construction of sewers by relief workers is economically sound but grading projects are not. Unemployment relief in Oakland accomplished more per dollar than CWA on sewer construction.

F. D. Bowlus, of Los Angeles County Sanitation Districts, described a project of sewer construction, estimated cost $80,000. The districts furnished pipe, supervision, and timekeeping. A trencher and backfiller were employed because of approaching winter. Cost by hand was sixteen times greater than by machine and men did not feel they were accomplishing anything when machine was not on the job.

W. A. Allen, of Pasadena, told of an experience in protection of banks of wash near the sewage disposal plant. A project costing $20,000 could have been done by machine for $1000. The city placed a barrier on part of the bank and that part withstood storm flows, but

the unprotected part went out during storms.

A short statement by W. F. Foster, of Los Angeles County, was read by Bowlus. Seven projects, involving construction of 125 mi. of sewer, ranging in size from 6 to 18 in., with ditch depths of 5 to 34 ft., were undertaken. Five thousand men were used, all work being done by hand. In spite of inexperience, delay by floods, and constantly changing labor, over 50 mi. of sewers were completed and ready for use when CWA was closed.

In discussion, president McMillan told of his experience in Ventura where only grading projects were approved and therefore no storm sewers could be constructed. He asked if other cities had similar experiences.

A. M. Rawn suggested that many of the difficulties were probably due to a misunderstanding of the purpose of CWA. Jobs of short duration were completed, but many projects were left unfinished because they were too large. Ribal stated that in Oakland so much money had been spent for relief before CWA was started that no funds were available for purchase of materials even though projects were approved by CWA.

J. C. Albers reported eight projects on roads and fire motor ways. He is a strong booster for CWA.

E. M. Hilton, of Yosemite, reported use of CWA labor on a variety of construction and maintenance projects. Men obtained were of high type and among them several were chosen to do technical work. The Park Service feels that it got its full money's worth.

M. R. Bowen, of Whittier, reported good work with CWA forces. All sewer jobs were completed and as high as 30% for material was obtained in some cases.

Miller read a brief statement prepared by city engineer Byxbee of Palo Alto, describing experiences with a PWA project on sewage disposal.

The meeting adjourned at 5 p.m.

Dinner Meeting

A group of 116 members and guests assembled in the Camp Curry dining room for dinner. Following the dinner short talks were made by president McMillan; park superintendent, C. G. Thomson; park engineer, E. M. Hilton; and prof. Hyde. Prof. L. B. Reynolds read the report of the committee on award and recommended:

1. That the Award of Merit for the year 1933 be made to the Yosemite plant.

2. That honorable mention be made to the Escondido plant.

President McMillan presented the plaque donated annually by Wallace & Tiernan Co. to Col. Thomson, who accepted with thanks and passed the plaque on to park engineer Hilton.

President McMillan announced that prof. Hyde's talk would be postponed until the morning session on Friday, and adjourned the meeting in time to allow members to view the fire fall from Glacier point.

Morning Session, May 26, 1934

The meeting was called to order by president McMillan. R. D. Pomeroy, research chemist, Los Angeles County Sanitation Districts, read a paper on "Oxidation Potential Theory Applied to Sewage." He outlined the theory of oxidation-reduction reactions, giving illustrations commonly known to sewage works operators. A cell was constructed, consisting of a solution of septic sewage and one of aerated water with copper plates for electrodes, and used to operate a delicate motor. The septic sewage was then aerated and after equilibrium was established, the motor stopped. While the energy available from sewage is large, it does not appear practicable to recover power. A measure of oxidation potential may be made in a manner similar to the determination of pH. Methylene blue is a commonly known indicator of oxidation potential. Dyes are also available for the determination but more data is needed to determine their ranges.

E. A. Reinke expressed appreciation for the paper which, though quite technical, gave promise of valuable information for future use. Alva J. Smith stated the contents of the paper were excellently prepared and throw light on things we need to know about in our work. A. C. Beyer stressed the need for a distinction between oxidation-potential and b.o.d., just as we distinguish between pH and total acidity.

President McMillan reported that D. M. Forrester was ill and could not prepare the paper scheduled. T. R. Haseltine had been injured and was also unable to attend the meeting.

A discussion of Alva J. Smith's paper* on "Utilization of Sewage Gas" was started by J. F. Byxbee. He summarized results reported by Waldraven at Springfield Sanitary District, and noted operations at Birmingham, England; Berlin, Germany; and Newark. He also quoted from papers by Glenn D. Holmes and A. P. Banta, explaining their experiences with use of sludge gas. He concluded that there appeared to be no insurmountable difficulties in using sludge gas and gave data to show estimated savings from its proposed use at Palo Alto.

M. L. Crist stated reports he had obtained from various sources indicated power could be developed at a cost of 1 to 1½c per kw-hr., including interest and depreciation. He reported a Ford engine operated 3 or 4 months at Salinas on sludge gas, showing no apparent deterioration of running parts.

F. S. Currie reported his only experience with use of sludge gas was at the San Bernardino plant. A 40-hp. gas engine was operated continuously for eight months, but when the Edison Co. gave a low power rate with high standby charge, its use was abandoned and it has only been run off and on for the past 5 years. It is now proposed to use the gas for killing dogs and also to fuel an animal incinerator.

* See California Sewage Works Journal, Vol. VI, No. 1.

A. P. Banta discussed his experiences with use of gas at the Los Angeles County Sanitation Districts. Variations in composition and effect of hydrogen sulfide must be considered in gas utilization.

After a short recess, prof. C. G. Hyde gave a talk on his trips east during the past 4 years. He described briefly the activities of the Federation of Sewage Works Associations and the meetings of the Board of Control. Newer developments in the field of sewage disposal include various systems of chemical treatment, incineration of sludge, and spray-drying of sludge. There is a lively interest in sewage disposal problems throughout the country.

In closing the meeting, president McMillan thanked those members who arranged the program, the authors of the papers, the Committee on Publications—Bell and Wintersgill, the Committee on Award—Hyde and Reynolds, and the Committee on Local Arrangements—Hommon and Hilton. He also thanked A. G. Darwin for his work in publishing the journal.

The meeting adjourned at noon.

In the afternoon several members visited the Wawona tunnel and inspected the ventilating equipment; also driving to Wawona and Mariposa Big Trees. Water supply, sewage disposal, and incinerator equipment were explained by H. B. Hommon.

Weather conditions forced the cancellation of the outdoor barbecue at Glacier point. An indoor barbecue around the fireplace at Camp Curry was attended by 45 members and guests. Mrs. Curry welcomed the members to the valley. D. M. Tresidder, president, Yosemite Park & Curry Co., entertained with a series of legends of the Yosemite Indians. Park naturalist Bert Harwell and his rangers entertained with whistling and song numbers, until time for the fire fall and the feeding of the bears.

On Sunday a group of members visited the Hetch Hetchy sewage disposal plant and the camp at O'Shaughnessy dam.

HANDLING FLOOD WATER AT A DISPOSAL PLANT, WITH COMMENTS ON THE NEED FOR GRIT BASINS

By A. W. WYMAN*

The old alibi, unusual weather in Southern California, is responsible for this paper and, in fact, unusual conditions are generally responsible for extremes in design and size to care for such emergencies which otherwise would be quite simple. Such a storm as New Year's Eve I am sure is unusual, records having shown it to be the worst in 50 years.

Loss of life and damage to property was terrible and also brought out the fact that our storm sewers were entirely inadequate to care for such a flood.

Where combined sewers are used a bypass is generally provided, primarily for storm-water control, but in many instances its use is very much abused. We could use one of these to advantage if we had one. Pasadena, like many other cities, has a separate system. Although offhand one would think this would eliminate any difficulty from storm waters affecting the disposal plant, such is not the case and in a storm such as New Year's it presented a serious problem. Ordinarily the difficulty is due to excess water reducing the detention period in our process tanks, and in the activated sludge process this is one of the main requirements for successful results.

Within certain limits storm water containing little solid matter can be taken care of. An ordinary storm increases our flow by about 3 m.g., but New Years the Parshall flume gage reached its recording limit of a 21-m.g. rate and our final estimate was 25 m.g.

With a minimum detention period of 4 hours the plant capacity is approximately 10 m.g.d., and our average flow is 8 m.g.d. From this you can readily understand how badly the plant was overloaded during this storm.

It doesn't seem possible that so much storm water can find its way into our sanitary sewers, but steep grades and many miles of paved streets with inadequate storm sewer catchbasins result in streets flooded from curb to curb. Manhole covers are perforated and water literally pours through them at such times.

During the New Year's downpour, storm water overcame the capacity of the sanitary sewers and manholes on the lower levels were shooting water 4 or 5 ft. high from the holes in the covers. However, activated sludge held intact in reaeration tanks, by reducing the pumping rate from clarifiers, soon returned the process of clarification to normal after the rain was over.

Although little organic matter is carried in storm water, immense deposits of sand are washed into the sewers during hard rains.

* Superintendent, Pasadena Sewage Disposal Plant.

When the plant was built, considerable study was given to the necessity of a grit chamber, but owing to complications in controlling such a variable flow it was not considered advisable to include one at that time.

Later when a grease trap was added to the plant, it was also found to make a very fair grit chamber under ordinary circumstances. Once a week this trap is emptied of a truck load of sand deposited by dry-weather sewage. Previous to this, several tanks had to be emptied to remove sand twice a year, which otherwise seriously interfered with aeration.

After the January storm the necessity for a real grit chamber seemed imperative.

Most of you know we manufacture a fairly high-grade fertilizer from the plant sludge which is guaranteed to contain 6% nitrogen or more. This fertilizer is about 75% organic matter and 25% mineral. Immediately after the storm the nitrogen content in the product dropped to less than 5%, much to the dismay of our fertilizer sales manager. This product would have to be disposed of as low-grade material without the name Nitroganic or tags bearing the higher guaranteed analysis.

We tried to console him with the prediction that this condition would only last a day or two, but when the nitrogen content again reached 6% we had on hand some 100 tons of low-grade material.

Maybe I shouldn't give away this sales secret, but we really made money on the increased tonnage due to the sand compared to the loss of 1½% nitrogen sold on a unit basis. Regardless of this high finance, I believe grit chambers are a great asset to any plant of our size or larger. Tons of sand were removed from the grease trap during this time, and by the large pieces of sewer tile and debris caught by bar screens we thought at first some sewer line must be broken.

As to design of grit chambers, I am very much impressed with the one described by H. Blunk in the Federation 'Sewage Works Journal' of May 1933, p. 509, and one couldn't go far wrong in following this type of construction.

To us another interesting feature caused by the storm was the very marked reduction in screenings. Average daily screenings up to January first had been between 5 and 6 tons. During the month of January this dropped to 50% normal. February was 70% and screenings remained about that until the middle of March, when it again reached normal tonnage.

I suppose the scouring effect of the storm and then the depositing of solids to fill the thousands of pockets in our miles of sewer lines must be the answer to such a result. It is really a wonder our sewage reaches the plant in such fresh condition with such deposits in our lines. These pockets must hold the many valuables which are lost in house sewers, because until this storm, none to my knowledge has ever reached the plant, although many inquiries are made

as to such a possibility. A lone diamond, so far unclaimed, did make the trip without losing its dignity or value.

Although this particular experience of handling storm water in a disposal plant was ours, it might or might not affect plants of different design or locality. Still it does bring out the fact that surplus capacity and a well-designed grit chamber would be a decided advantage in any plant for such an emergency, which may not wait another 50 years to pay us a visit.

DISCUSSION OF WYMAN'S PAPER BY HAROLD F. GRAY*

Harold F. Gray called attention to the economics of storm-sewer design. He stated that it has been customary to design for a storm intensity which might be expected once in a definite period of years, 20 years being a frequent assumption. Such assumptions are purely arbitrary, and are not based on observed and recorded facts as to the amount of actual storm damage. In the case just discussed a definite amount of storm damage has occurred, which can be closely estimated. The intensity of the storm is known, and its probable frequency in years can be deduced from the local rainfall records. It is possible also to estimate the cost of a storm-sewer system required to avoid the damage caused by this storm in this area, and to analyze the storm cost against the sewer cost in such a manner as to arrive at the maximum storm intensity (and storm frequency) for which it is economical to design. The engineer who will make and publish such an analysis, based on observed facts, will make the engineering profession his debtors.

Concerning storm-water overload at sewage treatment plants, Gray was of the opinion that adequate flood by-passes should be provided in all cases, discharging the flood overload into adjacent channels which are flood-ways in times of large storms. In practically all cases the by-passing of flood overloads from sewage treatment plants can be tolerated by the health authorities, under proper precautions, because such discharge will not appreciably increase the general pollution of all flood waters. On the other hand, such by-passing would result in appreciable economies in plant design and operation, without detriment to the public health, or the creation of any nuisance.

* Consulting sanitary and hydraulic engineer, Berkeley.

PATENTED IDEAS IN SEWAGE TREATMENT

By R. F. GOUDEY*

How many persons here would select a patented treatment plant over one without patents provided both produced the same results at the same cost? Again, how many persons here have treatment plants which are not controlled in some manner by patents?

Many prominent engineers have in the past been opposed to designing treatment plants which utilized patented processes or patented apparatus and also have frowned upon other members of their profession in patenting new and useful ideas in sewage treatment. It is rather curious to note that those engineers who openly express prejudice against patents are the most frequent to violate their stand by the adoption of those types of treatment plants which are most patented. In fact, one little realizes how far patents have made inroads into sewage treatment until an actual survey of the number of patents and what they cover has actually been made. It wasn't so many years ago when only septic tanks were patented, but at the present time about every conceivable type and sub-type of treatment has been covered with patents. Because of the fact that the Activated Sludge Inc. has brought suits against the cities of Milwaukee and Chicago we have been made to realize that patents do have something to do with sewage treatment. As a matter of fact, the Activated Sludge Inc. holds but twelve out of nearly five hundred patents, which indicates that the problem of this particular company is small as compared to the patent situation in general.

The Dorr Co. is rapidly building up a strong patent structure and has acquired fifty patents and is in the process of acquiring fifty more. About two-thirds of the Dorr Co. patents are machine or apparatus patents which deal with devices and equipment, whereas the remainder deal with treatment plant processes. Of the five hundred patents pertaining to sewage treatment probably about half deal with sewage treatment processes. In general, the price paid for the machine and apparatus patents is included in the price of the purchased equipment and is easy of collection. Process patents are usually covered by royalties, which are often difficult to collect.

In reviewing the patents on sewage treatment it is found that they start in with removal of grease and grit and wind up with sludge incineration or dehydration. The most important patent on grease removal is one by Dr. Imhoff. The patent for the removal of grit with mechanical devices and washing the sand free of organic matter is held by the Dorr Co. There are over five patents for self-cleaning bar screens such as the Evers-Savage, the Johnson, and the Los Angeles type, all of which have different features for self-cleaning and automatic operation. At the present time there is probably no

* Sanitary Engineer, Los Angeles Department of Water & Power.

automatically operated self-cleaning bar screen which is anywhere near as efficient as those which have been patented. There have been a great number of fine screens which have been patented, including the Dorr, Reinsch-Wurl, Rex, Bowles, Tark, and others. While the process of screening has not been covered with patents, nevertheless the most efficient devices for screening used in sewage treatment are patented.

When it comes to the clarification of sewage there are a host of patents. Septic tanks were patented very early in the development of the science of sewage treatment and they are covered by literally dozens of patents, including claims for anaerobic digestion, position of baffles, methods of construction, and various claims almost impossible of accomplishment. While there are different patented settling tanks of other types which developed between the time of septic-tank craze and the adoption of the Imhoff tank, their discussion is not pertinent because of their being out of date.

There is no doubt that the Imhoff tank outnumbers all other installations of any other patent device in sewage treatment. This patent is held by the Chemical Foundation and it covers the digestion of sludge in a lower compartment which is separated from the settling chamber above by a baffle which diverts scum developed during sludge digestion to separate scum areas in the tank. Since the original patent was granted a number of subsidiary patents have been added in recent years, including scum collection, heating of sludge, short sludge detention with removal to a third compartment, and provisions for intermittently shutting off the flowing through chamber and the sludge compartment at the slot level. There are many instances where the Imhoff tank makes an ideal installation. Nevertheless, it should be remembered that it is a patented article, although it is said the time for royalty collection has expired.

The next major development in settling sewage was the appearance of the separate sludge digestion process. This process is covered with process as well as machine patents. The general process of settling sewage in one basin, the removal of mechanically collected sludge into separate tanks alongside for digestion, and the return of supernatant liquor to the settling tank is known as the Morgan patent and is held by the Dorr Co. The Dorr Co. also holds patents for the mechanical mixing of sludge in a digestor. At the outset one might think that the separate sludge digestion process is controlled by the Dorr Co. In a sense it is, but the Dorr Co. sells licenses to other companies such as Chain-Belt, Johnson-Pulley, and others permitting them to quote prices on their own patent pieces of mechanical equipment. In one case it has settled with one of the larger companies so far as past violations are concerned. There are several companies at the present time which are not licensed by the Dorr Co. to place their own equipment in clarifiers and litigation is going on between them. There are over eight types of patented apparatus for the removal of sludge from clarifiers which deal with the methods of col-

lecting the sludge, manner of drive and in the scheme used for scum collection. In addition there are two classes of patents for Tray-Clarifiers which likewise come under the general Morgan patent.

When it comes to high-grade treatment plants there are fewer patents than in connection with preliminary clarification. Contrary to popular opinion there are relatively few patents dealing with the activated sludge process. The process patents, however, are rather general, three of them being as follows: First, the suspension of activated sludge in aeration tanks; second, the separation of activated sludge from aerated sewage in settling tanks; and, third, the return of thickened activated sludge conditioned or unconditioned to different parts of the treatment plant. The greatest number of patents in connection with the activated sludge process deal with machine patents on methods of settling, sedimentation, and aeration. Using compressed air for aeration there are five patented types of diffuser plates, several types of diffuser tubes, the Manchester type of aeration, and use of the air-lift principle with cascading aeration as developed by the Southwest Engineering Corp. Mechanical aeration has also been developed by many patents using pumps, buckets, scoops, paddles, etc. There is a patent on the combined use of compressed air and mechanical agitation. There are a number of patents on aeration by jets, brushes, etc.

Sprinkling filters, except under special cases of operation, have not been patented but they are practically controlled by apparatus patents. When it comes to dosing the filters one usually uses the patented automatic Miller siphons, the patented twin dosing tanks, or the patented Adams distributor. A device which is equally efficient in large plants and which is not patented but does not seem to be generally adopted is the dosing by parallel-operated butterfly valves regulated as to the number in operation and properly timed with sewage flow so as to be oppositely and continually opening and closing. Such a device, as developed in Baltimore, appears satisfactory. When it comes to small plants, however, this method of dosing is not practical.

The sprinkling filters are again covered with about ten patented types of sprinkling nozzles covering self-cleansing features, length to which sprays carry, size of spray drops, ease of removing spindles, and operation with minimum loss of head. Different types of underdrains have also been patented. Sprinkling filters which operate at high rates of treatment as an adjunct to other types of preliminary treatment other than sedimentation have been patented. The use of special gravel and slag for sprinkling filters is said to be patented. Sprinkling filters in the Middle West are invariably equipped with glass-covered sludge drying beds, of which there are several types of construction with different provisions for ventilation and heating.

Many are the patents dealing with chemical treatment. Among other things these patents cover the use of different coagulants, recirculation of chemical sludge, the addition of chemicals after prelim-

inary treatment, and the regeneration of coagulants. Recently the Guggenheim process has been developed for the removal of ammonia from the final effluent. The use of zeolites for ammonia removal and the regeneration of zeolites is patented by others than the Guggenheim Foundation. Disinfection by chlorine is not patented, but the only practical apparatus available for that purpose is patented. The use of chlorine in the thickening of activated sludge is covered with a pending patent. When it comes to digestion of sludge one runs into patents covering separate sludge digestion, mixing, and return of overflow liquor.

The dewatering of raw and fresh sludge with or without chemical treatment with vacuum equipment has been developed separately by the Dorr, Oliver Filter, Wright Filter, and Genter companies. Dorr and Oliver have united so far as filtration work is concerned and are concentrating on the Oliver equipment for vacuum filtration of sludge. The drying of sludge in spray driers is covered by two different patents, whereas rotary drying in kilns is patented by three or more firms. A method of incinerating pounded sludge cake in a ball mill and a method for recovering end products through the distillation of sludge and screenings is patented, but so far there are probably no installations in actual practice of either idea. Such items as the development of power and thermophylic digestion are covered by patents.

It definitely appears impossible for one to design an efficient treatment plant using the knowledge as developed at the present time or to construct a high-grade sewage treatment plant using modern principles of treatment without utilizing one or more of the existing patents dealing with sewage treatment. If one were to design a treatment plant totally devoid of patents he would be retrogressing to days when the following plan was in vogue: use of plain settling tanks operated intermittently; hosing of fresh sludge into lagoons; and use of crudely-dosed sprinkling filters. Such a plant would require a large area, would probably be a nuisance, would require considerable isolation, and would have a high installation cost. It is inconceivable that one would have to revert to such savagery in the design of sewage treatment plants.

Are we in the clutches of those holding patents on sewage treatment? The answer is No. The distribution of patents shows that no one firm holds a sufficient number to monopolize the field. Should we continue to ignore patents and try to design plants devoid of them? We find we are too late to attempt following out such a policy. We have now reached a point where we must play ball with those individuals and companies who are reasonable in their patent requirements and lay a certain foundation by which other patents can be circumvented or defended. Each operator and the designer of each treatment plant should be aware of every patent process or apparatus used in his particular plant and know what substitutes could be made and how to defend any patent suits should they occur in the

future. It is incumbent upon the operators and engineers to be on the alert and to prevent the public treasury from being raided. A study of the patent situation shows there is no cause for alarm, but it is desirable that operators and engineers should become patent conscious.

In step with the general trend throughout all branches of engineering there has been a greater activity of late in patents for sewage treatment. Recent years have seen structural engineering affected by patent designs in reinforcing and patented methods of concrete construction. Highway engineering is practically made up now of patented pavements. Airplane design and construction is literally a conglomeration of different patents. It is common knowledge that large telephone companies control all patents dealing with communication and that other commodities used by the public are controlled 100% by those firms having monopolies through patent holdings. In connection with sewage treatment there are a great many patents but there is no monopoly.

A study of the patents shows that there has been a healthy progress and development made in improving the efficiency of sewage treatment and lowering the cost of operation. A study of patents likewise shows there is a considerable choice in the selection of patents to avoid falling into the clutches of spoilers. One way of avoiding infringement of one patent is to secure protection under another. It, therefore, is the duty of the operator and engineer to study the patents in general and to intelligently apply them.

The original intention of this paper was to list by number the more important patents used in sewage treatment and correlate them with the actual plants in operation. It was also thought that a history of the development of sewage treatment could be traced through the development of patents. However, the writer has been warned not to open up the patent situation as it really exists and to avoid listing of patents, interpreting them, defining their scope, or placing limitations on them.

The suits of the Activated Sludge Inc. against Milwaukee and Chicago appear in the minds of some engineers and operators to be paramount. The Activated Sludge Inc. is said to have endeavored to sell their patents to one or more of the large commercial companies dealing with sewage equipment, but so far without avail. While these suits do have some bearing on the patent situation in general, nevertheless the problem at hand is far deeper.

The Dorr Co. in their patent structure has been most reasonable in licensing other companies and in the charges which they make for their own patented equipment. At the present time, however, they are involved in litigation with one or more of the larger manufacturers of mechanical equipment used in sewage treatment and it therefore becomes inappropriate to discuss those matters in this paper. There are a number of private individuals desiring to unload their patents on various commercial companies. At the same time there is

a desire on the part of the larger companies to buy up and corral as many of the important patents as possible. In fact, the time is ripe for a turnover in the ownership of a great number of these patents and the combining of them into one or more structures for further development. The statements made in this report, therefore, are not to be construed as having any authority whatever, nor are they to be used in any way in connection with any of the present patents under litigation.

The present patent situation then can be divided into three distinct headings. First, the activities of Activated Sludge Inc., which constitutes a problem by itself; second, the important patent structure of the Dorr Co., which apparently has been built up for the purpose of protecting as much as possible the up-to-date methods of sewage treatment and preventing exploitation of the public; and, third, a group of individual patents held by various individuals and companies, some of which have decided merit.

The present Activated Sludge Inc. is said to have been formed by a group of attorneys in exchange for legal services with the owners of the patents of the Activated Sludge Ltd. of England in the prosecution of its case with the City of Milwaukee. In the Milwaukee suit not all of the patents of the Activated Sludge Inc. were submitted for validation. The lower court decided in favor of the Activated Sludge Inc. The appellate court sustained the decision of the lower court and those patents submitted have become validated. It is understood that when the City of Milwaukee failed to settle with the Activated Sludge Inc. the latter brought an injunction suit against the city from operating its sewage treatment plant. The judge not being able to stop the operation of the treatment plant required the city to put in escrow a sum stated to be less than $300,000 until a decision could be made. This matter is still pending. The basis of settlement appears to be a charge of $0.30 per capita connected to the plant plus an item of 3% of the total cost of the plant. This should not be taken as a basis of settlement for any other plant. In the meantime, this company brought suits against the Sanitary Districts of Chicago alleging infringement of patents validated at Milwaukee and further asked for the validation of other patents, such as the Manchester type of aeration, not involved in the Milwaukee suit. The judge intimated that the patents validated in the Milwaukee case would not be reconsidered, it being up to him only to determine whether infringement has occurred, but that he would have to pass on the alleged infringement of the additional involved patents. Decision in this matter has not yet been rendered.

The Activated Sludge Inc. is not a commercial concern and its patent dealing with suspension of activated sludge in aerating tanks is said to expire next October, whereas the one for separating activated sludge from aerated liquors is said to expire November 1935.

As stated previously the most fundamental patents of the Dorr Co. include separate sludge digestion, thickening of sludge prior to

digestion, and digestion of sludge in which there is mixing of sludge and return of supernatant liquor to the process. The Dorr Co. also holds the so-called Imhoff patents for mechanical aeration of sewage. In fact, it probably holds more patents than any other single company on sewage treatment process and mechanical devices used in sewage treatment.

This company has made a practice of obtaining process patents and apparatus patents parallel with its development in sewage treatment work which it has been conducting since it has taken over sanitary work. This company has secured a number of very important process patents and licensed other companies making apparatus which falls under the process patent which the Dorr Co. holds.

There are a number of miscellaneous patents which are very vital in sewage treatment. It is now beyond the scope of this paper to list these for fear of improperly interpreting some of them or of casting limitations on others or of unintentionally not citing all which have merit. There is no harm, however, in mentioning the floating roof of the digestor, the patent for which is now held by the Pacific Flush Tank Co.; the tray-clarifier of the Pacific Flush Tank Co.; the direct oxidation process, and the Guggenheim process. There is one important patent held by Dr. Imhoff which provides for aeration of settled sewage and the return of all sludge to the raw sewage. This is not an activated sludge plant in any sense of the word and it gives an effluent which is probably somewhat better than just preliminary clarification. There are also patents on different types of treatment plants which produce a high-grade effluent in the summer time such that the method of operation can be changed in the winter time to have only preliminary sedimentation. There are a great many patents which are impractical when applied to the science of sewage treatment as now developed. There really is an amazing lack of foolish patents which are so characteristic with patents in other lines of activity.

In the design of treatment plants we must now make a selection of the process which best fits in with the local requirements and then take into account the license and process patents which are involved. Naturally those companies which keep their royalties and license fees at a minimum are those which will get the future business. The engineers and operators should be on the lookout for the royalties charged for different processes which they have to make settlement on. In general it is advisable to avoid patents held by patent attorneys or individuals as contrasted with those held by commercial companies. The former may try to collect damages which might ruin the future application of the patents in question, whereas the latter do not wish "to kill the goose which lays the golden egg". Likewise, it is advisable to know when patents are to expire, because those holding patents soon to expire are apt to make claims for all the traffic will bear.

The main duty, however, of the engineers and operators is to be

prepared to protect the city where alleged infringement of patents has been made and to advise the city how to best circumvent any litigation where exhorbitant fees have been asked. Regardless of the company which alleges infringement the general advice which the city should follow is the same. On receipt of a notice of a letter where infringement of patents has been received, that notice or letter should be submitted to the city attorney or a patent attorney who should work in close harmony with the engineer familiar with the treatment plant and the operator of the treatment plant in question.

Too often the city is advised to ignore these notices, which is a serious error. The manner in which this preliminary notice is handled determines to a great extent the line along which the patent settlement will be made subsequently. If the notice is ignored and the patentees finally win judgment, then the city is liable for damages for 6 years prior to the date of notice provided the plant has been in operation for that period. A proper procedure is for the city to reply that they are surprised that their treatment plant infringes on any patents that have not been settled and that time is asked in which they can make investigation to determine whether or not they are infringing on the patents in question and to ask for time in which to correct their treatment process so that there is no longer any infringement. An extension of time is usually granted in such cases. If, during the investigation, it is found that it is cheaper to make an amicable settlement such, of course, obviously should be done. Invariably, however, some way can be found in which to circumvent the patents and have the case properly prepared in the event that the patentee brings the matter up in court.

There are many ways in which a number of the most important patents can be circumvented. Obviously it is beyond the scope of this paper to expose such findings but the line of logic to be followed is the same. For instance, assume that a filter operating on fresh sludge needs to have paper pulp added to it. This process is patented and Wright, the patent holder, openly states that it can be gotten around by adding paper pulp to the outfall sewer uptown some place. Another method in circumventing patents is to produce a process which is in advance of the one under patent. In connection with activated sludge no one can prove to any court what activated sludge is. By developing a process which utilizes enzymes or a machine which brings about precipitation of colloids through any other explanation than that of activated sludge obviously constitutes a different treatment process. When such additional processes cut the aeration period from 6 hours to ½ hour, assuming, of course, that such is possible, a decided improvement over the first patent is established and is, therefore, in itself subject to being patented.

An example of how patents can be granted on establishing improvements and greater efficiency in treatment, although it does revoke the original patent but so complicates the original patent that it becomes practically valueless through the new patent is seen in a

discussion of aeration of sewage. At first sewage was aerated with air at about 2 cu. ft. per gal. The Manchester type of aeration was developed, which reduced the consumption to 1 cu. ft. per gal. Then the combined addition of air and mechanical aeration cut this consumption to less than ½ cu. ft. per gal., with a reduction of power requirements to about 15 hp. per m.g.

A new aerator has been developed which is a series of curved scoops taking air from the surface, but so designed that the air is moved into the center of the rotating device, which eliminates power in taking the air down to the half depth of the tank. The air on forcing itself through one perforated vein is caught about a foot higher by the one next above it, which brings it down where it is again discharged through perforations. The saving in power on moving the air in toward the center of the rotating device and of recompressing it through a 1-ft. differential rather than taking of all free air at the top gives a 50% saving in power over the compressed air plus paddles method of aeration. In addition this method of aeration gives an intimate mix of air and sewage by forcing both simultaneously through small holes, and it also gives a gentle floculating action in the remainder of the tank. Such development as this constitutes invention and gives an example of the tendency in the obtaining of new patents for sewage disposal.

In dealing with patents one has to recognize that the other fellow knows something about sewage treatment and that if one's ideas are to be protected they must be patented. Patents have dominated all other lines of engineering endeavor and are reaching a point in sewage treatment where recognition of them must be given proper consideration.

SLIME GROWTHS IN SEWERS

By F. E. DE MARTINI*

Slimes adhering to the inside of sewers may consist of sewage solids, fungus growths, or both. This paper deals primarily with slime growths or fungi. They are flowerless plants having the special characteristic of absence of chlorophyll, or green coloring matter, and starch. Hence, one conspicuous attribute is their gray, whitish, or brownish color and their slimy nature. Being devoid of chlorophyll they are unable to assimilate inorganic matter and consequently lead either a saprophytic existence, living on dead organic matter, or a parasitic existence upon a living host. Some of them—those in which we are interested—may live a semi-aquatic life.

Though in some instances the growths are intensely aggravating in a sewer system or to sewage works operators, the troubles they cause are comparatively uncommon and usually not continuous. In this paper I shall attempt to describe briefly some members of this group of organisms, review the experience of the Bureau of Sanitary Engineering with such growths in sewers and in streams, and mention some of the methods that have been tried to overcome them.

A number of organisms are involved, among which are Cladothrix and Sphaerotilus, which may be the same organism, Leptomitus, and Beggiatoa. Sphaerotilus natans is the so-called sewage fungus. This fungus appears as a dirty, cotton-like, gelatinous mass growing in oozy blankets or as long fragments sometimes likened to sheep's tails. Color varies from pure white, to gray, brown, and sometimes even a dark red. Under the microscope, S. natans appears as colorless threads showing a true branching which may be compared to a tree when the leaves are off. The filaments consist of rod or oval cells, surrounded by a thin, firm sheath. The organisms multiply by spores, thus they are resistant and not easily killed. Another well-known species is Sphaerotilus dichotomus. Microscopically it is distinguished from Sphaerotilus natans by its false branching rather than true branching. The threads or filaments appear to be branched but actually the apparent branches are cells which slip out of the sheath laterally and usually manage to break clear away; occasionally they cling to the sheath and form a thread adherent to the parent plant.

Another fungus which resembles Sphaerotilus both in appearance and in its habitat is Leptomitus. Visually it cannot be distinguished from Sphaerotilus, except possibly by expert biologists. Microscopically it is also a colorless, branched, threadlike organism, the threads being constricted at intervals into distinct segments with a conspicuous cellulin plug separating them. Sporangia or sacs containing the spores are found at the apex of the threads. Both of these organisms are aerobes. There are probably many variants. There are also many

* Junior Sanitary Engineer, State Department of Public Health, Berkeley.

forms of true iron bacteria and fungi, but except in special cases they are probably not found in sewage.

Beggiatoa is a third member of the sewage fungi or bacteria which grows principally in water containing sulfur compounds. It consists of short, compact, colorless threadlike filaments containing numerous sulfur granules, and exhibits an oscillating movement. It differs conspicuously from Sphaerotilus, lacking the slimy appearance. The most common species is Beggiatoa alba. This organism oxidizes hydrogen sulfide and accumulates sulfur in the form of small spheres, consisting of soft amorphous sulfur which never crystalizes in the living cells. It oxidizes the sulfur to sulfuric acid, which is at once neutralized, by the carbonates present, into sulfates. Without sulfur the organisms soon die off. They can even live and multiply in liquid containing only traces of organic substances. Approximate optimum reaction for growth is at pH 8. Beggiatoa is commonly found in sewage-polluted waters, but does not cause such difficulties as the large masses of Sphaerotilus.

The slimy Sphaerotilus or Sphaerotilus-like growths have been encountered in California both in sewer systems and submerged in the upper stretches of polluted streams ,and certain characteristics noted regarding their occurrence. These fungi grow best in water or sewage containing some dissolved oxygen and carbonaceous matter, and which are close to neutral in reaction. In California the majority of cases are found in the North Sierras where water supplies are very soft and cold and sewage is very dilute. European investigators report difficulties in growing the organisms in hard waters, but were able to do so in soft waters. Senft gives the chief habitat of these fungi in sewage, especially when containing carbonaceous wastes as from breweries and sugar factories, indicating that wastes containing carbonaceous material promote its growth. Being devoid of chlorophyll, they are unable to extract carbon from atmospheric carbon dioxide and therefore probably split it from carbonaceous matter. This too checks with our observations in streams receiving highly carbonaceous wastes as from canneries, wineries, and paper mills.

These organisms have given more or less trouble in the sewers, screens, tanks, or filters at Dunsmuir, Roseville, and Shastina, as others here will no doubt describe. I believe the Yosemite works can also point to some troubles. Occasionally one encounters references in the sewage works literature indicating difficulties of similar sort elsewhere. One case I recall was at the Des Plaines plant of the Chicago Sanitary District in 1927, where the light fluffy masses refused to settle in any stage of the activated sludge process. In this case the organism appeared to be a variant of Sphaerotilus.

At Choteau, Montana, a heavy growth in the sewage collection system was reported in 1922 and 1923. I believe also that Sparks, Nevada, has had an experience with Sphaerotilus. Reno is near Sparks and has a similar water. It would be interesting to hear from C. C. Kennedy, who is to discuss this paper, whether he knows of

experiences with Sphaerotilus at Reno that parallel those at Sparks.

It is somewhat curious, however, that not all places having an abundant, cold, soft water supply experience these growths in the sewage, indicating that an extremely delicate balance of several factors is necessary. For example, Folsom Prison sewage seems not to have Sphaerotilus though all factors seem to be right for it except that the sewer outfall is so short (only a couple of blocks long) that probably the dissolved oxygen is too high or the sewage is not in a state of suitable food supply for these organisms. In Roseville sewage the Sphaerotilus first appears about October 15, increasing gradually to December, then remaining fairly constant until February 1 and gradually disappearing by about March 15. Only one sewer line, to which an olive packing plant sewers, is affected. This suggests the olive plant wastes as one important factor. Olive meat contains carbohydrates which may be a source of carbonaceous material for the Sphaerotilus. It is interesting that the Sphaerotilus growths occur about the same time as the busy season at the olive plant.

As a general comment, the aggravating experiences of a sewage works operator having Sphaerotilus to contend with, include slimy accretions inside the sewers and often merely in particular runs of sewers, as at Roseville; breaking down of fragments and even huge patches of the mats of fungus which come down on sewage treatment works where they clog screens, form ugly floating masses on the surface of settling tanks, interfere with mechanical scrapers in settling tanks, choke filter nozzles and stone beds, and in activated sludge plants give a cloudy, bulked effluent.

Where there are reasons to anticipate these growths the design of sewage works and even the choice of process is involved. So far as I am aware, Sphaerotilus presents no problem in a digestor, probably because the absence of oxygen there is quickly fatal to it.

Streams showing Sphaerotilus are far more numerous than sewage works encountering it. Regardless of the location of streams or freshwater ditches receiving sewage or wastes from industries that release much carbonaceous matter, they may exhibit Sphaerotilus growths in varying degrees.

One at all observant has no doubt seen the gray mats and waving threadlike filaments attached to stones, twigs, and grass, below most sewer outfalls in fresh water where dilution is moderate. Even ditches carrying sprinkling-filter effluent show bits of gray fungus. The following cases are given as examples of Sphaerotilus growths in streams:

Auburn ravine is a creek having flow of around 20 c.f.s. in summer. It receives first the waste of a 45-ton peach cannery representing a population equivalent to about 6000. Then 3 mi. below is the septic-tank outfall of the town of Lincoln, with 2000 population. The dilution is about 2½ c.f.s. per 1000 population. The Sphaerotilus growths cling to debris along the banks and on the creek bottom below the cannery for several hundred feet, then gradually thin out.

The growth mounts again as the city outlet is passed, but is practically all replaced by green and brown algae ¾ mi. downstream. Over this stretch the dissolved oxygen, during a 2-day test period, varied from 12 to 75% of saturation.

Roseville sewage discharges to Linda creek. Sphaerotilus growths were found for a few hundred feet below the outlet, but 1 mi. below the outlet there was no sign of the organism. Creek flow here in terms of population was approximately the same as at Lincoln—roughly 2.5 c.f.s. per 1000 persons.

At Guadalupe raw sewage from the town and wastes from the Union Sugar Co. located at Betteravia, discharge to the Santa Maria river a mile or so from the ocean. Below the waste outlet the stream is a fresh-water slough. Sphaerotilus growths are common in the stream below the outlet and also in a ditch which carries the wastes from the sugar plant.

The profuse growths of fungus, principally Sphaerotilus, in Truckee river below the Crown Willamette Paper Co. plant at Floriston, California, led to a Federal injunction at the suit of the State of Nevada because of the great damage to the water supply of Reno, about 25 mi. below, and also because trout eggs were smothered and young trout were killed. Flow of the river in the driest months of the year was from 300 to 500 c.f.s. At the time the plant produced about 30 tons of sulfite wood pulp and 12 tons of ground wood pulp, yielding approximately 42 tons of paper per day. In this case the river looked like a stream of dilute dish water. Dissolved oxygen tests at the time showed approximately 70% of saturation and relative stability was 97%.

Mokelumne river for 20 mi. below Lodi was studied by the bureau last winter in connection with the discharge of winery wastes to it. Three wineries in the vicinity of Lodi and Woodbridge discharge plant wastes and still slops to the slightly turbid river. During the season of about 60 days, the three wineries crushed 21,600 tons of grapes, about one-third of which went to brandy production. From the studies the population equivalent of wastes from 1 ton of grapes seems to be about 33 persons, for wine making, and 225 in making brandy. The population equivalent of the entire operations was therefore about 30,000. River flow is 400 to 600 c.f.s. Hence the dilution in terms of population is considerable—roughly, 17 c.f.s. per 1000 population. But likewise the growths in the streams were markedly less than in highly polluted streams and were mainly confined to a narrow streak for a few hundred yards below each outlet where the growths attached themselves to twigs and weeds and resembled sheep's tails waving in the water. The coarse growths then ceased, but even as far as 17 mi. downstream fragments of the organism clung to vegetation along the banks, or floated with the water in quantities sufficient to impair the river for a water supply. Here, the Sphaerotilus growths act as indicators of organic pollution. A similar experience occurred in a small creek near Rutherford, a branch of the

Napa river. As a result of the growths, the winery was required to dispose of its wastes to land, by the Fish & Game Commission, due to harmful effects on fish. In Salmon creek, in the vicinity of the town of Bodega, Sphaerotilus growths occurred below a creamery which discharged wastes to the stream.

Another striking case of stream pollution was Kings river at Reedley, several years ago, when two or three canneries were operating there and sewering to the river. They were handling around 100 to 150 tons of fruit per day, representing a population equivalent of perhaps 15,000 to 30,000 people. The river flow may have been 200 c.f.s.—roughly, 6 to 12 c.f.s. per 1000 population. The water was sparkling clear, showing no signs of pollution, excepting the fungus growths. The fungus accretion on submerged twigs and branches of trees and water weeds, grew to the size of a man's head for miles downstream. Gradually the clumps would disintegrate and float away.

The habits of growth and the influence of environment and food supply suggest several control measures. Even normal sewage evidently contains enough carbonaceous waste to support some Sphaerotilus if other conditions are right, but if there is reason to suspect some especially important source of carbonaceous matter which can be cut off, the worst of the growths may sometimes be gotten rid of. Any physical changes that deplete oxygen in the sewage or make it strongly alkaline or acid, likewise strike at contributing factors. That is probably the reason that at Dunsmuir metering of the water system with the consequent reduction in water consumption has been followed by no further trouble with the fungus. The more concentrated sewage rapidly exhausts the oxygen.

This suggests the blocking of a sewer for a period to allow the disappearance of dissolved oxygen and establishment of septic conditions. Such an environment should kill the Sphaerotilus growths. It is reported that at Dunsmuir, liming of a clarifier affected by the growths, seemed effective in its control. Here also hypochlorite of lime at a 2¼-p.p.m. dose fed into the sewer kept down the growth in the outfall. Two p.p.m. of copper sulfate fed into the sewer for 3 days is reported to have killed off the organism at Choteau, Montana. The sewer was first thoroughly flushed and cleaned, then each block of sewer was plugged and a strong copper sulfate solution was allowed to stand in contact with the growth for 15 to 20 minutes. Roseville also has used copper sulfate and it is likely Gilkey will tell us the details of their experience. Ruchoft & Watkins, in 'Sewage Works Journal', Vol. I, No. 1, report experiences that lime in doses of over 100 p.p.m. in activated sludge containing Sphaerotilus-like organisms reduced the growths and a 500 p.p.m. dose dissolved them. Aeration up to 120 hours helped but did not completely eliminate them. At a pH of 6.3 or less they were killed.

The slimy growths here discussed cause difficulties in some communities seasonally; in others they may occur under special condi-

tions. Those instances given here do not indicate a single formula to overcome the growths, but it is hoped this brief review may be of assistance where these growths may occur in the future.

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DISCUSSION OF DE MARTINI'S PAPER BY CHARLES GILMAN HYDE*

The author is to be congratulated upon his excellent presentation of the topic Slime Growths in Sewers. His paper is of very real interest and value in that it treats of the organisms concerned and of their environmental factors and conditions; it cites noteworthy examples of their excessive prevalence in this region; and it discusses their untoward effects.

The writer's first experience with a pronounced growth of one of these organisms was had at Westborough, Massachusetts, in April 1899[1]. At that time he was serving as an assistant engineer with the Massachusetts State Board of Health and was sent to Westborough to gage the flow of sewage at various points along the outfall sewer between the village limit and the treatment plant. The latter consisted of intermittent sand filters preceded by a relatively small and inefficient settling tank.

In this outfall sewer there were then occurring enormous growths of an organism affirmed by the biologists of that day to be Leptomitus. The outfall sewer was about 4700 ft. long, of which some 3000 ft. was laid through very wet gravel. The sewer, of vitrified clay pipe, was poorly laid and was badly connected with 19 brick manholes, 13 of which were in the 3000-ft. section in question. The total leakage of ground water into this section was about 600,000 g.p.d., equivalent to somewhat over 1,000,000 g.p.d. per mile of sewer. The pipe diameter was 15 in. The actual contribution of sewage from the town was found to be about 200,000 g.p.d. It will be observed that the sewage proper was diluted with about three times its volume of groundwater. The groundwater, coming from granitic sands and gravels, was very soft.

Leptomitus grew upon the inner surface of the pipe and at times its bulk was so great as to seriously obstruct the flow and force it to

* Professor of Sanitary Engineering, University of California, Berkeley.

discharge through the manhole covers. From time to time huge masses of the organism would become detached. These would be discharged upon the surfaces of the intermittent sand filter beds, completely covering them and preventing the passage of sewage into the sand. It was not unusual to see masses of Leptomitus as large as the entire fleece of a sheep and presenting almost exactly the same appearance.

In 1900 the 3000-ft. section of clay pipe sewer was replaced with cast-iron pipe having caulked lead joints. Although the connections between the new cast-iron pipe and the several manholes were not made water-tight and some leakage occurred at these points, the new construction eliminated the greater portion of the infiltration. As a result the organism practically disappeared and no further trouble has since been occasioned by it, either in the sewer or on the filter beds. It would be interesting if the critical factors of air and food supply for this organism could be determined in more or less definite terms.

For about 12 years (1917-1929) the writer was intimately concerned with the problem of the pollution of Truckee river by wastes from the sulphite and ground wood pulp and paper mills of the Crown Willamette Paper Co. at Floriston, California. During the period he had an opportunity to observe and determine the effects of these wastes upon the stream.

The Floriston plant, comprised of a sulphite pulp mill, a ground wood-pulp mill, and a paper mill, was placed in operation in or about the year 1900.

In a report dated May 1918 the writer briefly reviewed the complaints made with respect to the pollution of Truckee river by the mill at Floriston, as follows:

"The paper mill at Floriston has been operated by the Crown Willamette Paper Co. or by its predecessor, the Floriston Pulp & Paper Co., continuously since 1900. Complaints of the serious pollution of the river by the wastes from this mill have been made almost continuously since the date of the beginning of its operations. Most of these complaints have come from residents of the State of Nevada. From the paper mill at Floriston to the California-Nevada state line is a section of stream amounting to only 6.0 mi. Along the river this region is practically uninhabited. It is natural, therefore, that the deleterious effects resulting from the disposal of the paper-mill wastes should be felt mainly within the state of Nevada.

"The history of the complaints durirg the first several years of operation of the paper mill is not known in detail to the writer.

"In 1912 the condition of the river was the object of serious complaint on the part of the citizens of Reno. Representatives appeared before the California Fish & Game Commission and requested such action on the part of the commission as would prevent further pollution of the stream by the wastes in question. Subsequent to this complaint a careful investigation of the effects of these wastes upon fish and fish life in the river was undertaken by the commission. The results of these studies are embraced in interesting and valuable reports by F. A. Shebley and N. B. Scofield, dated December 1, 1912, and January 22, 1913, respectively.

"In 1914 the condition of the water supply of Reno became the object of serious complaint on the part of the citizens of that community and as a result thereof a complaint was made by the city and its mayor, Fred J. Shair, against the Reno

Power, Light & Water Co., which was heard before the Public Service Commission of Nevada on March 13-14, 1914. This complaint was concerned with that portion of the water supply of Reno and Sparks which is taken by the defendant water company from Truckee river through its Highland Ditch and Highland Reservoirs.

"In 1915, pursuant to complaints on the part of citizens of Washoe county and of the cities of Reno and Sparks, the Nevada State Legislature passed a resolution calling upon the state senators and representatives in the Congress to secure relief from further pollution of Truckee river by wastes from the mill at Floriston through proper legislation in that body.

"Again in 1915, pursuant to the suggestions of governor Boyle and attorney-general Thatcher of the state of Nevada, made to governor Johnson of the state of California, Arthur Arlett was requested to investigate the conditions of Truckee river above and below Floriston and report thereon to governor Johnson. This investigation was conducted on November 15 and Arlett's report thereon was dated November 20, 1915.

"Recently so serious have been the complaints regarding the pollution of Truckee river by the wastes in question that in 1917 the matter again came before the Nevada Legislature for action. Under date of March 23, 1917, a resolution calling upon the state of California to prevent further pollution of the stream was passed. On March 8 the Nevada Legislature passed an act authorizing the attorney-general to take such proceedings and commence and maintain such action as may be necessary to prevent or restrain the pollution of any public stream or streams in the state of Nevada or any public stream or streams running into, in or through the state of Nevada whether the source of pollution was within or without the state."

With further reference to this matter, the following excerpt is made from a report by the writer on the condition of Truckee river as of August 13-16, 1929, in relation to the operation of the pulp and paper mill at Floriston:

"Under date of February 15, 1918, a complaint was entered in the Supreme Court of the United States (October Term, 1917—Original No. 30, In Equity) by the state of Nevada vs. Crown Willamette Paper Co., praying for a permanent injunction prohibiting the defendant from depositing certain alleged deleterious liquids and substances in Truckee river (an interstate stream flowing from the state of California into the state of Nevada) to the injury of the state of Nevada and particularly of the domestic water supply of the cities of Reno and Sparks and other municipalities within the state of Nevada, and injurious to the fish life of said stream.

"Subsequently to this action, the defendant company undertook to remedy, or at least to improve the conditions set forth in the complaint above referred to and for this and other reasons, on September 1, 1927, a stipulation was agreed upon by and between the state of Nevada, complainant, and Crown Willamette Paper Co., defendant. This stipulation, among other things, provided:

(1) that at all times, pending the final determination of the case, filters and screens would be provided and operated to prevent wood pulp and fibre from entering Truckee river in Nevada;

(2) that all reasonable efforts would be made to discover a satisfactory method of disposal of the waste sulfite liquor;

(3) that at the call of the calendar of the October Term, 1929, the Supreme Court may enter an order granting a permanent injunction, under proper conditions, against the operation of the sulfite pulp plant unless either

(a) a new or different and acceptable method for the treatment of the wastes shall have been discovered and works for conducting the process shall have been constructed and placed in operation by April 1, 1929; or

(b) the sulfite mill shall have been dismantled.

"Under the terms of the said stipulation the defendant company made definite efforts to proceed in evident good faith, and, in addition to the improvements called for in (1) above, a new process for the treatment of the strong liquor was developed and a plant of suitable sort and of sufficient size to demonstrate the feasibility and general economy of the process was designed and erected. It was placed in operation on March 20, 1929, and was operated more or less continuously until July 31. On March 30 the state of Nevada was duly notified by the company that it had complied with the terms of the stipulation.

"During the early portion of April 1929 an investigating committee was appointed to inquire and determine whether or not the terms of the said stipulation had been or were being complied with and to report its findings to the Joint Legislative Pollution Committee of the state of Nevada. This committee was duly organized, it assembled in Reno on April 19, 1929, and proceeded to review the operations of the defendant Crown Willamette Paper Co. under the terms and requirements of the stipulation in question. The committee rendered its report under date of May 20, 1929. Among other things, holding in review all of the facts and conditions which obtained, it was recommended that a 'new stipulation be entered into by and between the parties and that the said stipulation embody the following features and conditions:

(1) That it shall hold for the term of one and one-half years from October 1, 1929, to April 1, 1931'.

* * * * * * * *

(12) That on or before October 1, 1930, the complainant prepare and submit a report setting forth the significant facts concerning the physical plant treating the spent sulfite liquor and the operations of the company with respect to this plant and waste matters discharged to Truckee river in Nevada as affected by the operations and undertakings of the defendant company."

These references have been quoted at length for the purpose of showing how serious were the effects of the mill wastes in question upon Truckee river and how difficult was the problem of control and disposal of these wastes under the physical and other conditions obtaining at and below Floriston.

The organism Sphaerotilus has long been associated with waters heavily charged with organic matter (cellulose and carbohydrates in general) and sulphur. The organism is so typically associated with waters into which sulphite liquors are discharged that in Germany it is called the sulphite bacillus.

In this connection it may be of interest to describe briefly the effects of sulphite pulp and paper-mill wastes upon Truckee river[2]. These gross physical and biological effects may be expressed in the following terms:

(1) The occurrence of floating masses and of clouds of paper-mill wastes in the waters of the stream.

(2) The presence along the margins of the stream, in the more quiet pools and eddies, of great deposits of flocculent, grayish debris, composed of wood pulp and of filamentous bacterial growths.

(3) The accumulation on the rocks, and on sticks and brush at the edges of the river, of streamers of bacterial growths, principally Sphaerotilus, a typical index organism of sulphite pulp-mill wastes; slimy, grayish growths, several inches in length, forming a foul, oozy coat everywhere along the stream wherever there is a suitable substrate for their attachment and growth.

(4) The disagreeable, mouldy taste and odor of the water, particularly that

from hot-water systems in houses where the water is taken directly from the river for domestic purposes.

(5) The surcharge of the sand and mud along the banks and bed of the stream with organic material in a state of putrefaction and decay, and with iron sulphide deposited in that process.

(6) The presence of immense numbers of sewage or eel worms (Limnodrilus and Tubifex) in the marginal soils and muds.

(7) The enormous increase in diatoms, and large numbers of ciliated Protozoa, such as Stylonychia, Paramecium, and other bacteria-feeding members of the saprophilic fauna.

(8) The significant increase in dissolved and apparent color; the former due to the wastes themselves and difficult of removal; the latter due to the discoloration of the rocky streambed.

(9) The condition, for several miles below the mill, unfavorable to the propagation of trout and causing the flesh of adult fish to have a very disagreeable flavor.

As indicated above, for a period of nearly 4½ months in 1929, reasonably effective procedures were adopted whereby the plant wastes, particularly the waste sulfite liquors, in considerable measure were kept out of the river. The stream responded promptly and by the end of the period had returned to nearly normal conditions. Sphaerotilus, the so-called sulfite organism, was only sparingly present and where found at all was generally in an attenuated condition. Only in isolated locations of small extent were vigorous growths found. Oligochaete worms, formerly abundantly present in the shore muds, were no longer in evidence. The dissolved color was low. Green algae were flourishing where before only Sphaerotilus was to be found. The taste and odor of the water were greatly improved.

For reasons whose recital would make a long story, the mill has now been dismantled and Truckee river has returned virtually to its pristine condition.

Here, again, with this organism as with Leptomitus, it would be interesting and valuable if the critical conditions of air and food supply could be expressed in fairly definite terms.

A word might be said further with reference to Sphaerotilus in activated sludge sewage treatment plants. There is some evidence that this organism may be associated with the condition known as bulking. Bulking, at times at least, can probably be attributed to the leakage of dissolved organic matter through the aerating tanks into the clarifiers, thereby affording sufficient food for the growth of Sphaerotilus or similar filamentous organisms[3]. Sphaerotilus seems to require, in addition to a suitable food supply, an abundance of oxygen and an alkaline reaction; in other words, a relatively high pH value.

REFERENCES:

[1] 1903 Report, Massachusetts State Board of Health, p. 431-4.

[2] Pollution of Truckee River by Wastes from the Paper Mill of the Crown-Willamette Paper Co. at Floriston, California, May 1918, by C. G. Hyde.

[3] Use of Activated Sludge Process Increasing, by W. Donaldson, Civil Engineering, Vol. 2, No. 3, p. 167, 1932.

UNEMPLOYMENT RELIEF, PWA, AND CWA SEWER CONSTRUCTION IN OAKLAND

By RAYMOND R. RIBAL*

The city of Oakland, in order to relieve those who were forced from their ordinary occupations by adverse economic conditions, constructed many long-needed sewers, widened and daylighted many outlying streets and roads, and cleaned creeks and waterways to better care for storm waters; before the advent of the PWA and CWA. Many interesting comparisons can be drawn from the work done by the City Relief and that done under Federal Aid. To make these comparisons I will review the relief construction in Oakland from its inception in November, 1931, through the PWA and CWA to the present date.

The city first met the costs of emergency relief by appropriations for materials from the Public Betterment Fund, and paid relief labor from the Emergency Fund. Beginning February 1933, Alameda county paid for the indigent labor and trucks on grading jobs only, from the proceeds of a relief bond issue, and the city supplied all the necessary tools and materials. The city has made application to SERA for $14,000 to cover 30% of the cost of relief labor employed between July 1 and November 27, 1933. The application has been approved, but the money has not been received by the city. The city has paid for all materials on sewer jobs constructed under CWA with the exception of one unfinished job and has contributed freely of its equipment to all CWA projects.

A bond issue submitted to the people December 19, 1933, for $700,000 for construction of storm sewers did not receive the necessary favorable two-thirds vote. Prior to the election, request was made for a grant of $300,000 from the PWA for purposes of defraying 30% of the cost of labor employed on the projects. The grant was approved by the government, but due to failure of the bond issue, could not be used. Consequently no PWA work has been done by the city of Oakland as a result of bond proposals.

The superintendents on the work and nucleus necessary to perform skilled labor on the Unemployment Relief jobs were enlisted from the existing city forces. They were under the supervision of the Superintendent of Streets and Superintendent of Sewers. Many of these skilled men would have been out of work had they not been employed in skilled positions on the emergency work. On the CWA projects, city superintendents were taken over on the CWA payroll but functioned under city direction except for the period since February 15, 1934, when supervision was assumed by the CWA Administration. On each sewer job the city maintained a crew of three skilled sewer men to lay the sewer, make sewer joints, and build the necessary structures.

* Office engineer, city of Oakland.

Relief labor employed by the city from November 1931 until February 1933 was paid $3 for an 8-hour day and worked three days per week. By working three days alternately, twice as many men were given work as would have received work had the stagger system not been used. After February 2, 1933, at which time the city obtained county indigent labor, the 6-hour day was inaugurated. The daily wage remained at $3, but a two-day week was used, allowing three changes of crew, and again provided for a greater number of men. These wages are approximately 40 and 50c an hour compared to 60c an hour paid for common labor under CWA. The CWA also provided for a 30-hour week, thereby allowing for a little more than the absolute necessities of life provided for by the City Relief Construction.

On work done by the city previous to the CWA, men made application to the city for work and were required to fill out a questionnaire giving references who would certify to their need. If the questionnaire showed the man eligible for work and his references attested to his need he was employed. If after his employment he lacked inclination to work, allowing sufficient time for him to become adjusted to this character of work, he was discharged. By this method able and efficient crews were soon established.

Under CWA when once employed a man was given work until the termination of the job or until the general layoff due to tapering off of the relief work. In this manner the efficiency of crews did not approach that of the city crews previous to CWA.

The program involved the use of an unprecedented amount of hand labor on work that normally would be done by machine. The results obtained by hand labor in sewer construction have been favorable, contrary to general beliefs. In the construction of sewers all types of soil were encountered, except that rock was fortunately avoided but for one job under CWA construction. Occasionally where soil was unusually hard, where tunneling was necessary, when avoiding traffic tie-ups, and when breaking pavements, a compressor and air tools were employed. The depth of cuts varied from 4 to 20 ft., the deeper cuts requiring two lift platforms to raise excavated soil to the surface. Trucks were employed to haul away waste soil. The city trucks were augmented by additional trucks on jobs under CWA construction.

Of the 11.959 mi. of storm, sanitary, and combined sewers constructed by Unemployment Relief, 5.716 mi. was replacement of sanitary or combined sewers constructed in the early 1870s or before, many of which were broken down and required larger size. The diameter of the sewers ranged from 8 to 30 in.

Under CWA, 1.626 mi. of sewer has been completed ranging in size from 8 to 36 in. Two jobs, one a monolithic storm sewer 3 by 5 ft. and the other a precast storm sewer ranging in size from 54 to 15 in., are not included above and are not yet complete.

The following comparison of amounts expended for relief by the

city and CWA include only the expenditures directly under the supervision of the Street Department. The Playground Department, the Park Department, and others under both relief periods spent considerable sums of money. The work under the Street Department consisted principally of grading, street work, and sewers.

From November 15, 1931, until November 15, 1933, the city expended $257,901.27 for sewers out of a total of $329,104.77 spent for relief during the same period, or sewer construction accounts for 78% of the money expended.

The CWA spent $39,817.72 and the city spent $27,918.79 for sewers from November 15, 1933, to the present time, or a total of $67,736.51 was spent for sewers, excluding unfinished jobs. The total amount spent by the city and CWA for relief during this period was $991,846.35, or sewer construction accounted for only 6.8% of the money expended. These costs do not include the cost of CWA overhead, as they were compiled from duplicate reports of timekeepers and superintendents on the jobs.

Of the work done by Unemployment Relief, materials and equipment accounts for 41% of the expenditure, city labor 20%, and relief labor 39%, or labor received a total of 59% of the money expended. On the CWA work material and equipment accounts for 36% of the expenditures, city labor 6%, CWA labor 58%, or labor received 64% of the money expended.

While the larger percentage of the cost paid to labor in the latter case shows the trend due to higher wages and probable less efficient labor, it does not represent the difference as a whole. A larger percentage of the larger-sized sewers were constructed by CWA, which increases the cost of materials in proportion to cost of labor. The relative labor costs are discussed later.

In order to compare the economy of sewer construction over grading, comparison was made with respective contract jobs just prior to relief work or concurrent contract jobs in Berkeley. It was found that the cost of sewers constructed under Unemployment Relief and the 8-hour day exceeded the estimated contract costs by about 4% and that the sewers constructed under the 6-hour day exceeded the estimated contract cost by approximately 20%, the increased cost under the 6-hour day being due largely to the shorter day.

Good records were kept of labor costs and the number of cubic yards of earth moved on the three major grading jobs done under the Unemployment Relief. It was found that the cost per cubic yard of grading was $1.80. Just previous to this work, the city of Oakland contracted for two large grading jobs that were done for 23c and 20½c, respectively.

The additional cost of sewers does not seem excessive when the relief accomplished is taken into consideration, but the efficacy of grading by hand methods, despite the relief accomplished, demands serious consideration.

In comparing the relative costs of Unemployment Relief and CWA, the difference may best be shown by comparing the unit values for labor alone, as materials were practically constant during the construction period. Excavation and backfill under Unemployment Relief cost $1.50 per cu. yd. and under CWA cost $3.40 per cu. yd., or the labor cost was more than doubled under CWA construction. Some of this increase was due to higher wages, but the greater portion can justly be attributed to the conditions governing the selection and employment of labor that resulted in less efficient labor.

The construction of sewers is an economically sound relief measure. Grading projects, despite the large proportion of the cost going directly to relief labor, are not economical. Unemployment Relief sewer construction accomplished more per dollar spent than was accomplished by CWA sewer construction. The greater portion of the work done under CWA was of a grading nature, while that done by Unemployment Relief largely favored sewer construction.

SANITARY SEWERS CONSTRUCTED BY CWA UNDER SUPERVISION OF THE LOS ANGELES COUNTY SURVEYOR

By W. F. FOSTER*

In December 1933 the Civil Works Administration approved seven sanitary sewer projects for construction under the supervision of the Los Angeles County Surveyor. These seven projects were widely distributed throughout the county and provided separate sanitary sewer systems for the unincorporated communities of Belvedere, Lennox, Lomita, and Bellflower.

The seven projects contemplated construction of 125 mi. of sewer ranging in diameter from 6 to 18 in. and in depth from 5 to 34 ft., all being tributary to the Los Angeles County metropolitan sewer system.

Construction conditions varied greatly. In Bellflower groundwater and quicksand were encountered at a depth of 4 ft. In Lennox and Lomita the material varied from hard clay to soft loam; while in Belvedere hard decomposed granite was encountered which kept blacksmiths constantly busy sharpening picks.

Within a week 5000 men were at work on the seven projects, but in spite of the difficulties attendant to training so many inexperienced men in so short a time, good progress was made.

All work was done by hand labor, the largest equipment being pumps, joint-compound heaters, and small trucks for handling excess dirt, pipe, etc.

Although the full quota of 5400 men was not maintained on the projects at all times (less than half that number were available during certain periods of construction), and in spite of flood, inexperi-

* Engineer of Sanitation, Los Angeles County Surveyor's Office.

enced and constantly changing labor, and other difficulties, over 50 mi. of sewer was completed and ready for use when the CWA closed down on March 29, 1934.

Applications have been submitted to the SERA for the reopening and completion of these projects and, due to the fact that government purchase orders are outstanding for all of the materials necessary, we believe that the projects will eventually be completed.

EXPERIENCES WITH CWA IN CONNECTION WITH SEWER CONSTRUCTION

By FRED D. BOWLUS*

During the past 6 months the Los Angeles County Sanitation Districts have completed the construction of nearly 2 mi. of 33 and 36-in. 'vitraduro' sewer near Compton. Although application had been made for CWA labor, it was necessary, early in December, for the districts to commence the job because of the approaching rainy season. A large Austin trencher and a Buckeye crane were rented and a trained nucleus of a crew employed. Borings along the line showed that with the annual rise of the ground-water table considerable difficulty could be anticipated. For this reason the CWA officials finally granted authority to continue the use of these two major pieces of equipment when 6 weeks later they allocated 100 men to the work. These men were used for backfilling the trench and for general assistance to the districts' crew. Although the districts would have provided employment for more men, could they have been furnished, nearly 3000 man-days work were contributed by CWA forces prior to the general shutdown of all their projects about April 1.

Laying these large pipe, weighing up to 1½ tons, without proper machinery would have been very impractical. The trench was 5 ft. wide and averaged from 12 to 14 ft. deep. Most of it was dug with the excavator at a cost of 25c per lin. ft., including operator, helper, fuel, and rental charges.

One week while waiting on pipe delivery, the CWA men were set to work excavating a section of the trench by hand. This required one man a day to dig 1 lin. ft. and the cost was therefore sixteen times greater by hand than by machine. Estimated cost of excavation alone on this project, if done by CWA hand labor, would have been at least $50,000, whereas the total trencher rental bill was only $1350, twenty-nine 8-hour working days being required to complete the job. Similar comparison could be made of the cost of pipe-laying, timber removal, and backfilling trench.

Although some saving of funds accrued to the districts by use of CWA men, a large saving came about through the government's payment of equipment rental and fuel bills.

* Resident Engineer, Los Angeles County Sanitation Districts.

In providing this vast program of unemployment relief a psychological effect on the workman has been overlooked. One very noticeable thing on this Compton sewer job of the County Sanitation Districts was the half-hearted, depressed, listless manner in which the CWA crew worked when the machinery was idle and it was necessary for them to excavate and backfill by hand. Progress was too slow. A marked difference was noted in the esprit de corps the mornings the trencher and crane were started. Almost to a man they would jump in and eagerly do their assigned jobs, realizing that they were part of a machine accomplishing something worth while. At the end of those days they looked back with pride to 400 or 500 ft. of good-sized trench, securely braced with timbers, fine graded, pipe well laid up, and the smoky sulphur-pot joint crew struggling along in the rear.

NORTHWEST CONFERENCE ON STREAM POLLUTION

An organization meeting was held May 11 at Eugene, Oregon, resulting in the 'Northwest Conference on Stream Pollution', embracing the states of Oregon, Washington, and Idaho, for which a constitution has now been drafted. Recognition of the group for affiliation with Pacific Northwest Section, American Water Works Association, is being sought by a committee headed by Carl E. Green, state sanitary engineer for Oregon, and including: Roy M. Harris, state sanitary engineer for Washington; W. V. Leonard, state sanitary engineer for Idaho; Prof. Fred Merryfield, Oregon State College; Dean R. G. Tyler, University of Washington; Prof. J. W. Howard, University of Idaho; and Prof. M. K. Snyder, Washington State College.

Green presided at the Eugene meeting, attended by D. A. Dunkle, Brian Shera, and T. E. Moffitt, Tacoma; H. E. Dodge, Port Angeles; R. F. McLean, Walla Walla; Harris, George Mitchell, Woodworth Anderson, and E. A. Heiss, Seattle; Merryfield, David Charlton and E. F. Howard, Corvallis; Ray E. Koon, Portland; W. P. Hughes, Lewiston; J. W. Howard, Moscow; L. W. Coiner, Cottage Grove; G. M. Irwin, Victoria; O. C. Hopkins, San Francisco. T. R. Haseltine, vice-president, and directors Alexander Bell and Gilbert Darwin of California Sewage Works Association, were present to outline the history and activities of sewage works organizations in the Pacific Southwest.

OXIDATION POTENTIAL THEORY APPLIED TO SEWAGE

By RICHARD D. POMEROY*

Many of the phenomena observed in the treatment of sewage may be understood more clearly if they are explained in terms of oxidation potentials. It is the purpose of this paper to outline the theory, and to point out some deductions of the principles of oxidation potentials as applied to sewage and to furnish a foundation for further research in what may be a profitable field of investigation.

In the large class of chemical reactions known as oxidation-reduction reactions, as distinguished from metathetical reactions, electrons are transferred from one substance, the reducing agent, to another substance, the oxidizing agent. Any substance capable of absorbing electrons may act as an oxidizing agent, and any substance which can yield electrons may be a reducing agent. Some oxidizers show a very strong demand for electrons and are called strong oxidizing agents, while others take electrons only when they are easy to get. Likewise some reducing agents yield electrons freely, while others give them up only when a strong oxidizing agent is present to take them.

Among the oxidizing agents familiar to the sewage chemist, going from the stronger oxidizers to the weaker, are potassium permanganate, chlorine, oxygen, nitrates, nitrites, ferric iron compounds, sulfates, and a portion of the atoms in organic molecules. Among the reducing agents may be mentioned most organic matter, hydrogen sulfide, and ferrous iron compounds.

The strength of the oxidizing or reducing agents does not necessarily control the rate at which reactions will occur between them. It is necessary not only to distinguish the strong from the weak oxidizing and reducing agents, but also to distinguish between those which tend to react very rapidly and those which react but slowly. Permanganate, chlorine, nitrite, and ferric compounds tend to react rapidly if reducing agents which are reasonably reactive are present; oxygen and nitrates react less rapidly; while sulfates and organic oxidizing atoms are rather unreactive. Of the reducing agents, ferrous iron and hydrogen sulfide are very reactive, but the organic matter, while in general strongly reducing, reacts quite slowly.

If a random mixture of oxidizing and reducing substances such as those named above is prepared, the strongest and most reactive oxidizers and reducers will first neutralize each other, then slower reactions will destroy the agents which are not quite so reactive, until a point will be reached such that either all of the active reducing agents are consumed, with some active oxidizing agent left over, or vice versa. Suppose that an active oxidizing agent such as chlorine

* Research Chemist, Los Angeles County Sanitation Districts.

does remain, but that only quite unreactive organic matter remains of the reducing agents. The oxidizing agent will cause the solution to show a demand for electrons. The organic matter will be willing to supply these electrons, but can only do so very slowly, so that the reaction will be very slow or imperceptible. This condition of electron demand will constitute an oxidizing environment, and it could be said, for reasons which will be evident further on, that the solution has a high oxidation potential. If, on the other hand, some relatively active reducing agent is left over at the end of the period of rapid reaction, the solution will then be characterized by the relative availability of electrons and will constitute a reducing environment or will have a low oxidation potential. The principal factor determining whether the solution shows a hunger for or is glutted with electrons is not whether substances are present which are potentially able to take or yield electrons, but rather which one of the substances present is able, because of its reactivity, to dominate the situation.

The complex mixture known as sewage is just such a mixture as that discussed, with the added complication of the presence of micro-organic life. All living things except those which effect photosynthesis depend principally upon oxidation-reduction reactions for the energy required for their life processes. They are able to live by catalysing reactions which would otherwise go imperceptibly or not at all. For example, there is very little reaction between oxygen and the organic matter of sewage in the absence of micro-organic life. But micro-organisms presumably produce enzymes, or organic catalysts, which have the net result of causing a reaction between the oxygen and organic matter at an appreciable rate.

Consider a sample of sewage which has been chlorinated to a residual. The mixture will be strongly oxidizing due to the presence of free chlorine. The residual will react slowly with the organic matter until no chlorine remains. Chloramine and hypochlorite, if present, will also be reduced. The oxidizing potential will drop to a lower value. Oxygen, if present, will then control the potential. (The actual potential of aerated water or sewage is far below the theoretical potential of the oxygen electrode calculated from free energy values, but the oxygen probably controls the potential by the influence which it exerts over other active substances.) Bacterial activity will now proceed—supposing that the mixture is not entirely sterile—causing more of the organic matter to react with the oxygen until no oxygen remains. After this, ferric iron, nitrates, and nitrites will be reduced. When these oxidizing agents are gone, the solution will be relatively reducing, due to the presence of ferrous iron, to enzymes which are themselves reducing compounds, and to reactive decomposition products of the organic matter which has been split up by enzymes. At this stage certain bacteria will take advantage of the oxidizing capacity of sulfates and will reduce sulfates to hydrogen sulfide. This latter substance, being a reactive reducing compound, will depress the oxidation potential to a low value, and much

lower than this it probably does not go. The last stage of activity is the interaction of oxidizing and reducing atoms of the organic matter, manifested in the process known as anaerobic digestion, with the formation of carbon dioxide and methane.

If the reasoning set forth in the foregoing discussion is correct, the ability of sewage to absorb or yield electrons should be demonstrable. A solution cannot yield electrons unless some provision is made for neutralizing the electric charges involved. This can be done if one leads the electrons from a reducing solution through a metallic conductor to another solution which can absorb them, placing this solution in turn in juxtaposition with the first solution in such a manner that the charges can be neutralized by the migration of ions, but so that the solutions cannot freely mix.

An arrangement which affords an interesting demonstration for the sewage chemist may be made from septic sewage and aerated water. One of the solutions is placed in a porous cup and this is placed in a beaker containing the other solution. Copper plates will serve for electrodes. This set-up constitutes an electric cell, identical in principle with all other electro-chemical cells for generating current.

(Note—In a demonstration at the California Sewage Works Convention at Yosemite May 26, 1934, such a cell was constructed and used to operate a delicate electric motor. In a trial run at the laboratory of the Los Angeles County Sanitation Districts the motor was operated 6 days on the energy from a pint of settled sewage.)

The fact, as demonstrated, that electric power can be generated from such common things as aerated water and sewage, immediately arouses curiosity as to how much power might be made available in this way. Suppose that one is dealing, as at the plant of the Los Angeles County Sanitation Districts, with a flow of 15 m.g.d. with a 20-day b.o.d. of 500 p.p.m., and that 400 p.p.m. of this b.o.d. can be concentrated to a sludge and satisfied in an electric battery. This would produce a current of 3,200,000 amp. There are indications that the satisfying of the b.o.d. could be done at a potential difference of about 0.4 volt. This would indicate a power of 1280 kw., or about 1700 hp. Large as this figure is, it does not appear practicable to recover power in this manner because of difficulties which undoubtedly would be experienced, principal among which would be the area of the necessary electrodes. Furthermore, it is only necessary to allow the sludge to undergo digestion with the production of methane gas, which, when used as a fuel in internal combustion engines, may be made to produce a substantial amount of power (about one-third of the estimated electrical power at the plant noted) in a manner less complicated and involved. It would not be possible to obtain both electrical energy and combustible gas from the same sludge, for if the sludge were electrically oxidized the only gas obtained would be carbon dioxide. Power development upon the basis of electrical oxidation may still, however, be a possibility worth further investigation.

While a practical application of the oxidation-potential theory does not appear promising in the direction of power development, it seems probable that a knowledge of the values of oxidation potentials in various phases of treatment of sewage may prove of value when correlated with other phenomena.

The oxidation potentials have many analogies with pH values. The pH or hydrogen-ion concentration values measure the supply and demand of hydrogen ions, which are essentially protons, or elementary particles of positive electricity. The oxidation potential measures the supply and demand of electrons, which are elementary particles of negative electricity. Each micro-organic species has a limited range of pH within which it can grow. Likewise each micro-organic species is limited to a certain range of oxidation potential. The germicidal effect of chlorine can be explained in terms of the fact that it raises the oxidation potential to a value that destroys germs.* The essential difference between aerobic and anaerobic forms of life is primarily a difference in the range of oxidation potential within which they thrive. Many species which have been considered obligate aerobes doubtless could grow in the absence of oxygen if other substances were present which would maintain the oxidation potential at a sufficiently high value. In many cases it probably is not the element oxygen which is required, since combined oxygen is abundant in any case, but rather some substance which can take electrons, and yet not take them too avidly as chlorine would do. These considerations may make clear the extent to which an understanding of oxidation potentials is important in sewage treatment.

In order to apply this knowledge a method is needed for numerical evaluation of the oxidation potentials. In the construction of a cell such as that described for the demonstration of potential differences in sewage, if one uses instead of aerated water some solution whose electron demand is fairly constant and reproducible and which can be accepted as a standard, then the oxidation potential of the sewage can be defined as the e.m.f. of this cell. It is because the supply and demand of electrons can be measured in this way in terms of e.m.f. that it is called a potential. If for the standard solution one uses a solution containing hydrogen ions at an activity of 1 normal, and saturated with hydrogen gas at one temperature pressure, one is then using the accepted standard of reference for all such work, and the e.m.f. of this cell may be taken as the oxidation potential of the unknown solution. In actual practise it would be simpler to use the calomel half-cell rather than the less convenient hydrogen half-cell, since the relations of the calomel half-cells to the hydrogen half-cell have been carefully determined in the scientific laboratories of the world.

The oxidation potential of the solution being tested may be either

* Schmelkes, F. C., "The Oxidation Potential Concept of Chlorination"; Am. Journal Public Health and Nation's Health, 23 (3) 268, '33.

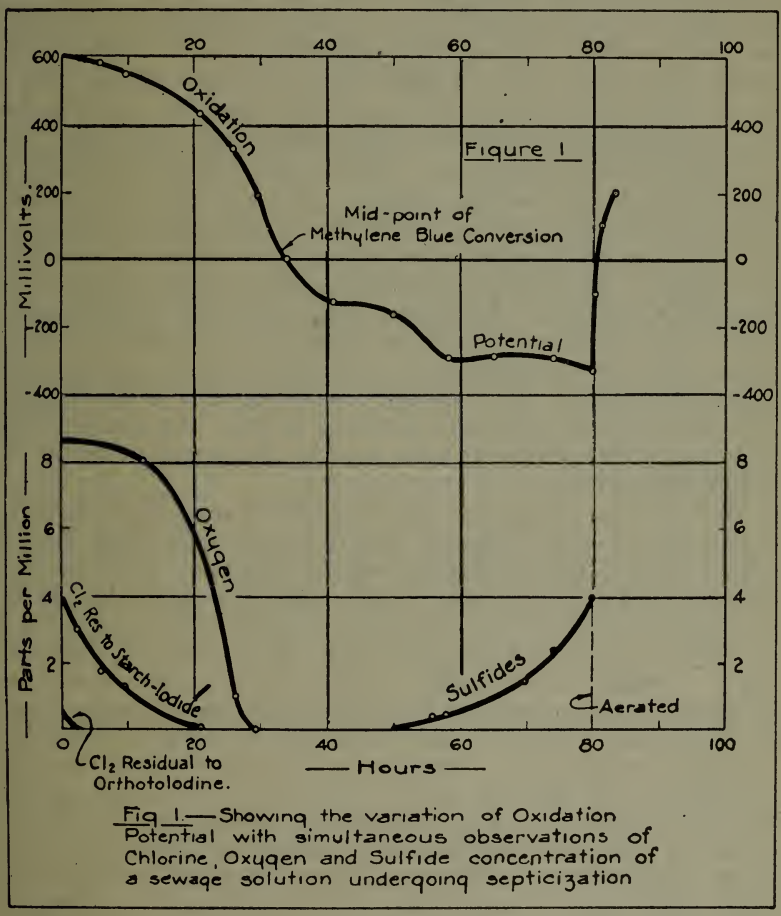


Fig 1.—Showing the variation of Oxidation Potential with simultaneous observations of Chlorine, Oxygen and Sulfide concentration of a sewage solution undergoing septicization

positive or negative in relation to the hydrogen half-cell. There is no essential difference between positive and negative oxidation potentials, any more than there is between positive and negative temperatures on a thermometer.

In an exploratory experiment at the laboratory of the Los Angeles County Sanitation Districts, the change of the oxidation potential with time was followed electrometrically, and concentrations of some of the active constituents were followed simultaneously, with results as shown in Fig. 1.

The equipment for the electrical determination of oxidation potentials is not generally available in sewage laboratories. Another method may be used which is very simple, although not as accurate as the electrometric method. This simple method is by the use of potential indicators. Just as there are many dyes which may take on or set loose a proton (or hydrogen-ion) and in so doing change color, so also dyes are available which will change color upon taking on or setting loose an electron. Some of the potential indicators are known already to the sewage chemist. For example, in determining chlorine residuals use is often made of orthotolodine in hydrochloric acid. If the potential is high enough so that there is free chlorine in the solution, this mixture will turn yellow, while at lower potentials it will be colorless. Potassium iodide and starch serves a similar purpose, but in this case the color change is at a substantially lower potential. The color of the sewage itself serves as an indicator if much iron is present. If a sewage containing iron is black, one can be quite sure that the oxidation potential is low. An excellent potential indicator which has long been used by the sewage chemist is the dye methylene blue.

Methylene blue changes to colorless after the oxygen, the nitrates, and the ferric iron are reduced, but it is not until some time after the dye bleaches that hydrogen sulfide appears. The dye is half changed to the colorless state at +11 millivolts when the pH is 7.0. (As to the effect of pH on oxidation potential indicators, see Clark, "The Determination of Hydrogen Ions", Third Edition, 1928, p. 367 et seq.) It might be desirable in some cases to use a dye which would change color nearer to the point of disappearance of oxygen, or in other cases to have an indicator which would show when hydrogen sulfide first appears. There is an inviting field of research on the application, in such cases, of some of the potential indicators which are being developed in the scientific laboratories. Several good indicators of this class are now on the market. There is a series of substituted indophenols in the range above the methylene blue point, although their color changes are not as satisfactory as might be wished. For investigations in the region of negative potentials there is available a splendid series of four sulphonated indigos, which change from blue at the higher potentials to yellow at lower potentials. The color change in each case can be observed over a range of about 80 millivolts.

It is probable that methylene blue will continue to maintain its position as the best indicator for a general estimate of stability, but other indicators may be valuable for auxiliary tests.

This study of oxidation-potential theory suggests other possible applications whose practicability remains to be tested. Determination of the oxidation potential may provide a quick method of determining the presence or absence of dissolved oxygen or hydrogen sulfide in sewage in various stages of treatment. Tracing the changes of the

oxidation potential may provide an easy method for determining the rate of certain biochemical reactions, and may be a useful analytical method in estimating the degree of contamination of sewage.

Summary

Oxidation potential is a measure of the electron demand. An oxidizing environment is one in which electrons are scarce, while a reducing environment is one in which electrons are plentiful.

The oxidation potential of a solution is controlled by the dominance of the most active constituent. If a sample of sewage chlorinated to a residual is allowed to stand and become septic through bacterial action, the potential follows a general downward course, being dominated in succession by chlorine, oxygen, and hydrogen sulfide.

Electrical power can be generated directly by electrical oxidation of sewage, but the prospects of profitable power development do not appear promising.

Oxidation potential values can be estimated by potentiometric methods and also by the use of dyes which serve as indicators in a manner similar to the pH indicators.

Appreciation is expressed to A. M. Rawn and A. P. Banta for assistance in the preparation of this paper and in the experimental work relative thereto, and to Carl Tennant for construction of the motor.

DISCUSSION OF POMEROY'S PAPER BY A. C. BEYER*

The author is to be complimented on the clear presentation of his subject. Pomeroy is unquestionably correct in indicating the necessity of distinguishing between oxidation potential and either total oxidizing power or b.o.d., similar to the very analogous distinction between pH and either total acidity or alkalinity. The suggestion for further research in this field as related to sewage disposal is an excellent one.

The author suggests that the germicidal effect of chlorine can be explained in terms of the fact that it raises the oxidation potential to a value that destroys germs. With this I cannot entirely agree. It has been definitely shown that several oxidizing agents stronger than chlorine—that is, having a higher oxidation potential than chlorine—do not have even the same sterilization or germicidal powers shown by chlorine. Although there are a number of theories concerning the details of the process, I believe it is generally agreed that chlorine acts, not by oxidation, but by a direct combination with the bacterial cell wall, which might be described as a poisoning process. However, the author's statement is partially correct since, as Schmelkes has pointed out, oxidation potential shows a relation to velocity of sterilization when chlorine and chlorine compounds, such as chloramines, are compared.

* District manager, Wallace & Tiernan Sales Corp., San Francisco.

DISCUSSION OF ALVA SMITH'S PAPER ON TROUBLES WITH UTILIZATION OF SEWAGE GAS

By J. F. BYXBEE*

The paper prepared by Alva J. Smith last fall and read at the Santa Cruz meeting, on troubles with utilization of sewage gas†, was very interesting and instructive, particularly to those who are studying this by-product of sewage treatment works. It pointed out the present difficulties to be expected in the utilization of the gas for internal combustion engine operation and for heating purposes, but Smith noted that these difficulties might be overcome by scientifically directed engineering skill.

During the last few years, particularly, engineers and chemists have been earnestly working to find a practical use for sewage sludge gases and many experiments, many on a rather large scale, have been made for using the gas for heating and power purposes. Some of these appear to be quite successful, while others apparently are experiencing difficulties.

In addition to the gas-engine experience at Rockville Center, N. Y., and the boiler heating results at Los Angeles and Pomona, cited in the paper by Smith, we have a number of other recent reports on sewage gas utilization which might be briefly mentioned as follows:

W. B. Walraven, engineer of the Springfield Sanitary District, reports in a paper read before the Illinois Society of Engineers, January 31, 1934, on the use of sewage sludge gas to drive a large internal-combustion engine. This engine has been in successful operation for a year.

No evidence of damaging corrosion due to the gas has yet been found. If hydrogen sulphide is present in excess of 0.1% by weight, scrubbers are recommended, but none have as yet been installed at the Springfield plant. Reports are that the saving in cost of power is such that the entire investment in the engine unit, $15,728, can be written off in 3 years and still show good interest return. The engine drives a blower to deliver air to the aerators. Gas production averages 0.6 cu. ft. per capita per day.

At Birmingham, England, a gas engine of 950 b-hp. is said to be in successful operation, and a 1750-b-hp. engine is operating in Berlin, Germany. The writer has no information concerning the degree of success that is experienced in the operation of these engines.

A sludge gas engine (Fairbanks, Morse Z-type 15-hp. with high-compression piston) was installed at the Newark, N. J., sewage treatment plant in 1932 to operate a Roots-Connorsville positive displacement blower. This engine-blower unit was guaranteed to deliver 360 c.f.m. of free air at 350 r.p.m. against a pressure of 5 lb. and with a

* City engineer, Palo Alto. † See this Journal, Vol. VI, No. 1.

fuel consumption not greater than 11,000 b.tu. per b-hp. at full load.

In a paper presented at the New York State Sewage Works Association in June 1933, by Glenn D. Holmes, consulting engineer, the following comments in reference to operation of this engine were made:

> The most vexatious experience in connection with operation of the sewage treatment plant has been with the gas engine. Continuous operation of the engine during any month reduced the power bill by one-half. The principal trouble with the gas engine has been due to pitting of the exhaust valves, causing loss of compression. The gas has been unusually high in H_2S, which burns slowly and is not fully consumed within the cylinder, causing trouble in the exhaust piping and heat exchanger.
>
> These troubles have been at least partly corrected by substituting new exhaust valves of higher heating resistance, increasing the temperature of the circulating water in the cylinder jacket from 120° F. to 150° F., and changing the exhaust hook-up to the exchanger.
>
> The heat exchanger developed a leak and has been temporarily disconnected. It appears that most of these troubles may be traced to the H_2S content of the gas and scrubbing may be necessary. A survey of the sewer system is to be undertaken in the near future to determine, if possible, the source of the sulphates.

Tests seem to indicate that the H_2S in the gas amounts to 2.4 to 3.4% by volume, which is very high.

A. P. Banta, assistant engineer, Los Angeles County Sanitation Districts, reports in 'California Sewage Works Journal', Vol. 5, No. 1, on the temperature control of a sludge digestion unit by means of a hot water system, utilizing sludge gas for fuel. The boiler used is a vertical fire-tube type, containing some ninety 2-in. tubes After making minor adjustments at the start, the boiler functioned very satisfactorily for about 6 months. After that the efficiency dropped rapidly and the results were disappointing. Upon inspection of the boiler, it was found that the tubes were thickly caked on the outside with a combination of soot and a hard, gray crystalline substance tentatively classified as sulphate. These deposits were removed and the boiler is now cleaned regularly every 2 or 3 months, and no further crystalline material has been found on the tubes. The boiler was reported to be working perfectly.

Other performance records where the gas is used for heat and power might be cited, but in general they would be much the same as those given above and in Smith's paper. Hydrogen sulphide causes the major troubles where the quantity is more than 0.1% by volume of the gas. The scrubber appears capable of eliminating this objectionable gas at least to such a degree that corrosion from it will not be serious.

The city of Palo Alto is just completing the construction of a sewage treatment plant involving plain sedimentation and separate sludge digestion. The plan provides for a heating plant for the digestor, consisting of heating coils in the tank and a hot-water circulating system which would use sludge gas for fuel. Storage of the gas in a 2000 cu. ft. controller is provided for; also apparatus for

cleaning, scrubbing and burning the gas in such a manner as to give practically automatic control of the digestor temperature.

Recently the Palo Alto City Engineer's office has been considering the gas-engine generating unit as a substitute for boiler equipment. The climate at Palo Alto is mild and not much heat will be necessary to maintain the digestor tank at a favorable temperature. Therefore, if no other use is made of the gas than for heating the tank, a great deal of it will have to be wasted. All of the sewage entering the plant has to be lifted against a head of 20 to 25 ft. into the clarifier, and in consequence the power bill will be an important item of expense unless sludge gas can be successfully used to perform the major portion of that work.

The experience that other plant operators and investigators have had in recent years relative to generating power with the gas engine and using waste heat from the engine to warm the digestor tank, encourages one to believe that such installations are proving successful and that economies are being effected in plant operation where gas fuel is being diverted to useful work.

An estimate of the value of this gas as fuel for a prime mover for the Palo Alto plant is as follows:

GENERAL DATA

Population served by sewer system—19,000.
Average quantity of sewage—1,500,000 g.p.d.
Peak maximum rate of flow—2,400,000 g.p.d.
Estimated amount of gas per day per inhabitant—0.5 cu. ft.
Probable total gas output per day—9500 cu. ft.
Estimated heat units in gas—600 b.t.u. per cu. ft.
Total heating units available per day—5,700,000 b.t.u.
Proposed capacity of generating unit—35 kw.
Kilowatt hours delivered daily by generating unit—240.

It is assumed that the engine will operate from 10 to 12 hours per day to carry the daytime load, and that power will be purchased from an outside source to carry the lighter night load.

Heat used by engine plant for power generation—3,500,000 b.t.u. per day.

Heat recovered in engine cooling water and transferred to digestor—Estimated 1,600,000 b.t.u. per day.

Heat unused would apparently be 2,200,000 b.t.u. per day, which would indicate a gas wastage of about 3600 cu. ft. per day.

GAS ENGINE GENERATING PLANT OPERATING COSTS

(Based on furnishing all power required at the plant from about 8 a. m. to 8 p. m.)

Labor (it is assumed that the plant attendant would look after the engine along with his other duties, and that no additional help would be required)	$ 0
Lubricating oil	75.00
Gas fuel (procured from plant)	0
Repairs	125.00
Supplies	30.00
Total	$230.00

The cost of a 50-hp. high-grade gas-engine generating set installed would be approximately $3200. Based on a life of 10 years and interest rate of 5%, the fixed charges would be $414.40 per year, which, added to the operating cost, would make a total yearly cost of $644.40.

A careful estimate of the amount the power bill, which will be about $1400 per year, would be reduced on account of the operation of the engine would be $930 per year, therefore the net saving due to the engine would be $285.60. This net result is not very startling in itself, but if the engine is to act as a heating element for the digestor in lieu of a gas-heated boiler plant, which would cost about 0.3 as much as the engine plant, it is seen that it would be proper to eliminate a portion of the fixed charges and repair and supply costs on the engine operation in order to make the cost of the two systems of heating comparable. In this event it might be inferred that the actual saving the engine would make in connection with the operation of the whole sewage treatment plant would probably be conservatively $550 per year.

In addition to this saving in the cost of operating the plant, the engine generating set would act as a standby service in case of a power shortage, which would be serious if the disturbance continued for many minutes at the Palo Alto plant.

The successful use of sludge gas for heating purposes and generating power has been demonstrated in a number of sewage plants in this country and Europe, and there appear to be no insurmountable difficulties in using the gas for such purposes.

Heating the digestor with hot water coils from a gas-fired boiler is the most common method of making use of the gas. During the last few years the use of sludge gas for power production has been tried and thus far good results have generally been reported. Such plants, however, have not been in operation long enough to determine clearly their dependability and length of life.

Where a considerable amount of power is to be used at a sewage treatment plant, the use of sludge gas for generating power might offer economic advantages in the operation of the plant as well as affording standby service.

Gas containing objectionable elements in comparatively large volume, such as H_2S, should be cleaned by passing through scrubbers before using.

THE RELATIONSHIP BETWEEN FREE HYDROGEN SULFIDE AND TOTAL SULFIDES IN SEWAGE

By RICHARD D. POMEROY

EDITOR'S NOTE—Richard D. Pomeroy is research chemist for the Los Angeles County Sanitation Districts. Pomeroy attended school at California Institute of Technology at Pasadena, graduated in 1926 with the degree of B.S. in chemistry, and in 1931 obtained the degree of Ph.D. in chemistry at the same school. From 1927 to 1931 he was instructor in chemistry at University of California at Los Angeles, resigning his teaching duties to accept his present position with the districts in 1932.

The relationship between free hydrogen sulfide and total sulfides in sewage appears to be of sufficient importance to warrant further discussion. The relationship is predictable from the known laws of ionic equilibrium, and has been confirmed experimentally at the laboratory of the Los Angeles County Sanitation Districts.

First consider the reactions which lead to the formation of H_2S. The generation of this objectionable compound is principally the result of the abstraction of oxygen from sulfates by the carbonaceous matter of the sewage, this reaction being brought about by bacteria. Ignoring possible intermediate steps, the reaction for the reduction of sulfate may be represented by the equation:

$$(1)\quad SO_4^{=} \rightarrow S^{=} + 4\,[O]$$

where $SO_4^{=}$ represents a sulfate ion, and $S^{=}$ represents a sulfide ion. It is not necessary to write any particular sulfate, such as sodium or calcium sulfate, since the positive ion makes little difference to the reaction. As soon as a salt like sodium sulfate is dissolved in water, it splits apart and thereafter the sulfate ion acts virtually as an independent substance.

The behavior of the sulfide ion which appears on the right side of the equation is not influenced by the metallic ion which may be present if the resulting sulfide is soluble. If the metallic ion can cause the formation of an insoluble sulfide, a precipitate will form. This is the case if ferrous salts are present, in which case the equation for the precipitation may be written:

$$(2)\quad Fe^{++} + S^{=} \rightarrow FeS$$

There is usually enough iron in sewage so that when it becomes septic and generates sulfides, it will cause the formation of some ferrous sulfide, a black, extremely fine precipitate which does not readily settle.

If the sulfide ion is not precipitated as in equation 2, then it will react with the hydrogen ions which are always present in water, even though at very low concentration, to produce hydro-sulfide ion and hydrogen sulfide:

$$(3) \quad S^{=} + H^{+} \leftrightarrow HS^{-}$$
$$(4) \quad HS^{-} + H^{+} \leftrightarrow H_2S$$

These latter reactions are reversible; that is, may go either to the right or the left (and for that matter reactions 1 and 2 may also be reversed under appropriate conditions). Reaction 3 goes almost completely to the right under ordinary conditions, while equation 4 goes only partially.

The sulfur compounds shown in the four equations comprise all of the known forms of any importance in which inorganic sulfur exists in ordinary sewage, namely, sulfate ion, $SO_4^{=}$; ferrous sulfide, FeS; sulfide ion, $S^{=}$; hydrosulfide ion, HS^{-}; and hydrogen sulfide. H_2S. The concentration of sulfide ion is negligible except at very high pH values (12 or above). Ferrous sulfide is insoluble. Thus there are only two soluble forms of inorganic sulfide which are of importance in sewage, hydrosulfide ion and hydrogen sulfide. The relationship between these two forms is important and can be calculated for any given pH value on the basis of the known ionization constant of hydrogen sulfide, which is:

$$(5) \quad \frac{(H^{+})\ (HS^{-})}{(H_2S)} = 9.1 \times 10^{-8}$$

The results of such calculations are shown in Table I.

TABLE I

pH	Percent of total dissolved sulfides in the form of:	
	HS^{-} %	H_2S %
5.0	1	99
6.0	8	92
7.0	48	52
7.4	69	31
8.0	90	10
9.0	99	1

This table allows one to draw some conclusions as to the rate of escape of sulfides into the air. This is a matter of importance, since many of the objections to H_2S are due to its presence in the atmosphere. Only H_2S can escape from solution into the air, but as fast as the gas escapes, more of the sulfide will change to H_2S to maintain the same equilibrium percentage, so that eventually all of it may be removed. The important fact is that the rate of escape, relative to the total concentration of sulfides in solution, becomes less as the pH is increased. The table shows that at pH 8.0 the rate of escape

will be only 10% as fast as in acid solution, and at pH 9.0 the amount escaping under most conditions will be negligible.

In order to demonstrate the validity of this theory, two tests were performed in which H_2S was removed from solutions by bubbling with inert gas (purified methane from sludge gas). The solution used in the first case was H_2S in dilute HCl, and in the second case was sulfide in a solution buffered to pH 7.4. The conditions of bubbling were kept as nearly constant as possible throughout the tests. The solutions had an average volume of 850 c.c. and the gas was passed at an average rate of 250 c.c. per minute. The bubbles were estimated to have a volume of 1.0 c.c. The initial sulfide concentrations were 17 p.p.m. at H_2S and 14 p.p.m. as H_2S. Small portions of the solutions were withdrawn from time to time and analyzed by titration with iodine solution.

It is to be expected that the rate at which H_2S is removed from solution under these conditions would be proportional to the amount remaining. If this is the case, integration of the rate equation yields the equation:

$$(6) \quad -\log \frac{C}{C_o} = K\,V$$

where C/C_o is the fraction of the original concentration remaining, K is a constant dependent upon the conditions of bubbling, temperature, and pH, and V is the volume of gas passed.

The results are shown graphically in Fig. 1. The curves are drawn to fit the form of equation 6, using values of K which best fit the experimental data. The values are 0.081 for acid solution and 0.0255 for solution of pH 7.4. Since these constants measure the relative rates of escape of H_2S in the two cases, the constant for pH 7.4, according to Table I, should be 31% of the constant for acid solution. Actually it is 31.5%. The agreement of these values is fortuitously closer than is significant for test of moderate accuracy, but the experiment is adequate to show that the theory is valid.

This treatment does not attempt to say how much of the sulfide will be volatilized in any given case. It is certain that under many conditions of aeration of sewage the sulfide is largely destroyed by oxidation, and that only a small part of it escapes to the atmosphere, although this small amount may be enough to cause serious difficulties. Only in very rapid and thorough aeration, as in spraying from nozzles, is it likely that the amount of sulfide escaping exceeds the amount oxidized. In any case, the amount escaping will be reduced by higher pH values, for not only does the higher pH retard the escape, but may also accelerate the oxidation. The practical importance and possible application of this conclusion is apparent.

A relationship between free H_2S and iron in solution in the presence of suspended ferrous sulfide can also be predicted from equilibrium principles. The relationship is expressed by the following

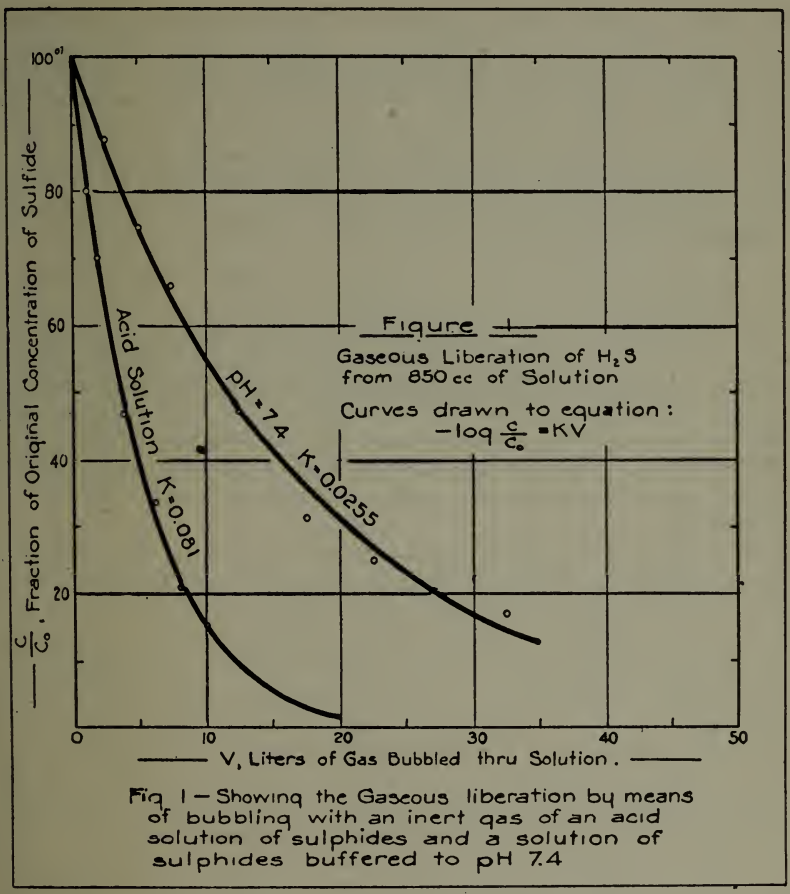


Fig. 1 — Showing the Gaseous liberation by means of bubbling with an inert gas of an acid solution of sulphides and a solution of sulphides buffered to pH 7.4

equations, in which (Fe^{++}) is the concentration of dissolved ferrous iron in p.p.m. and (H_2S) is the p.p.m. of free H_2S in solution:

$$(Fe^{++}) \times (H_2S) = 0.00065 \text{ at pH } 7.0$$
$$(Fe^{++}) \times (H_2S) = 0.065 \text{ at pH } 6.0$$
$$(Fe^{++}) \times (H_2S) = 6.5 \text{ at pH } 5.0 \text{ etc.}$$

The constants are calculated from the results of Bruner & Zawadski[1]. These expressions show that at pH 7.0 the quantity of free H_2S in solution must be very small if there is any significant amount of iron in solution, or conversely, if there is an excess of H_2S very little iron can remain in solution. But if the pH is 5.0, then the equilibrium concentration of H_2S will be substantial, amounting to 0.65 p.p.m. even when Fe^{++} is 10 p.p.m. Thus if a suspension of ferrous sulfide in a solution of pH 5.0 is bubbled with inert gas or otherwise exposed so that the H_2S can escape, the ferrous sulfide will progres-

sively dissolve as the H_2S is removed, and the removal of the sulfide will rather easily go to completion. Even at high pH values the sulfide may be removed by prolonged bubbling, and the removal from sewage may be more rapid than would at first appear, for other substances in the sewage may serve to prevent the concentration of ferrous ion from becoming very high. Thus phosphate, which is normally present in sewage, will tie up a part of the iron as un-ionized ferric phosphate, and organic compounds may also be present which are capable of combining with the iron.

An attempt is sometimes made to distinguish analytically between volatile and non-volatile sulfides in sewage. Two procedures have been suggested: (A) Total sulfide is determined on one portion by adding antimony solution and acid and comparing the color with standards. Another portion is aerated to remove volatile sulfide and the remaining sulfide determined as before. (B) The volatile sulfide is removed by bubbling with an inert gas to another solution where it is determined. The sewage sample is then acidified, the bubbling continued, and the additional sulfide recovered is reported as combined sulfide[3].

It is evident from the foregoing discussion that if the removal of H_2S is complete, no dissolved inorganic sulfide will remain. If suspended ferrous sulfide is present, the results will vary. If CO_2 is used to remove the H_2S, the pH of the sewage will generally be lowered to between 5.0 and 5.5 by the solution of CO_2 (calculated from the bicarbonate equilibrium[4]), and the ferrous sulfide will gradually be decomposed. If air is used, the ferrous sulfide will be slowly oxidized. This oxidation of ferrous sulfide in aerated sewage is usually complete in less than 30 minutes. If some inert gas such as nitrogen or purified methane from sludge gas were used, the pH would rise to 8 or 9 due to loss of CO_2 from the solution, and the removal of the last of the H_2S would be very slow and probably would be incomplete. The experimental quantity which is found for non-volatile sulfide may be due to incomplete removal of H_2S from the dissolved sulfides, to ferrous sulfide which is not completely decomposed or oxidized, or to organic sulfides which are decomposed to H_2S by addition of acid. It appears that the analytical distinction between volatile and combined sulfides will not be of much value unless a procedure is devised which has definite significance.

Summary

The only known forms of any importance in which inorganic sulfide sulfur can exist in sewage are suspended ferrous sulfide, and dissolved hydrosulfide ion and hydrogen sulfide.

As far as is known, all of the dissolved inorganic sulfide can be removed from solution as H_2S.

The rate of gaseous escape of the dissolved sulfides, other condi-

tions being constant, is proportional to the fraction of the sulfides which is in the form of H_2S.

The fraction of the sulfides in the form of H_2S can be calculated from the ionization constant of H_2S.

The predicted effect of the pH on the rate of escape of sulfides as H_2S has been experimentally verified.

Unless the escape of H_2S from solution during aeration is very rapid, the sulfide will be largely destroyed by oxidation in solution.

The analytical distinction between volatile and non-volatile sulfide is of doubtful value.

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NOTES

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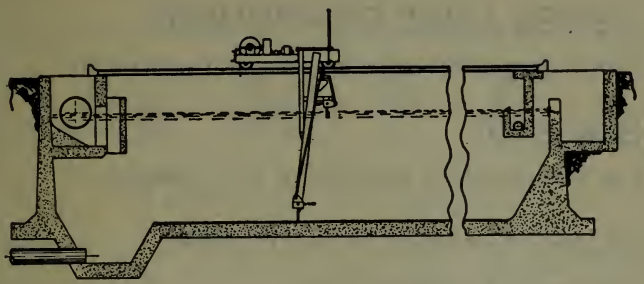
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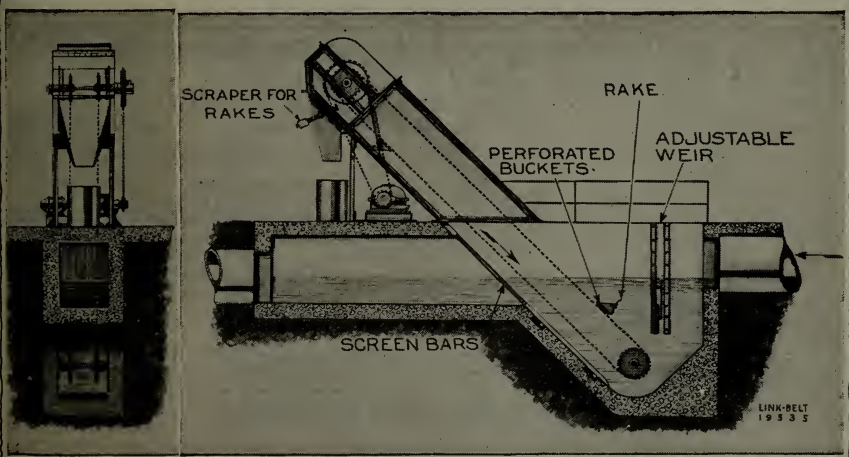
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CALIFORNIA SEWAGE WORKS JOURNAL

Official Publication of the California Sewage Works Association

Vol. VII • 1934 • No. 1

Minutes of the
Seventh Annual Convention at Pasadena

Experience with Sewage Farming in Texas, Arizona and California

Sewage Disposal—National Parks

Ocean Disposal of Sewage

Treatment of Beer Slops

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SEVENTH ANNUAL CONVENTION

Pasadena, September 5-6, 1934

Headquarters: Hotel Maryland

Program

TUESDAY, SEPTEMBER 4

6:30 p. m.—Public Health Engineering Annual Hi-Jinks Dinner, Crystal Room, Huntington Hotel.

WEDNESDAY, SEPTEMBER 5

9:00 a. m.—Visits to Pasadena Activated Slulge Plant and Beverly Hills Water Treatment Plant. Informal Luncheon at Beverly Hills.

1:00 p. m.—Visit Hyperion Screening and Incineration Plant and Los Angeles County Sanitation Districts Activated Sludge Plant.

Wednesday Night—Informal Get-Together Dinner, El Patio Restaurant.

THURSDAY, SEPTEMBER 6—*Morning*

9:00 a. m.—Civic Auditorium. Joint Session with Public Health Engineering Section, American Public Health Association; D. C. McMillan, presiding. 'Experiences with Sewage Farming in Southwest United States', by V. M. Ehlers, Chief Engineer, State Board of Health, Austin, Texas; F. C. Roberts, Jr., State Sanitary Engineer, Phoenix, Arizona; E. A. Reinke, Senior Sanitary Engineer, State Department of Public Health, Berkeley, California.

'The Treatment and Disposal of Sewage in the National Parks', by H. B. Hommon, Sanitary Engineer, U.S.P.H.S., San Francisco, California. Discussion, Arthur P. Miller, Sanitary Engineer, U.S.P.H.S., New York, N. Y.

'Sea Outfalls and Ocean Disposal of Sewage in the East and West', by A. K. Warren, Chief Engineer, Los Angeles County Sanitation Districts, Los Angeles, California. Discussion, S. A. Greeley, Greeley and Hansen, Chicago, Illinois. (Paper and discussion read by A. M. Rawn.)

'Disposal of Wastes from Breweries', by A. M. Buswell, Chief, State Water Survey Division, Urbana, Illinois. (Paper read by Mr. Le Bosquet.)

'Disposal of Wastes from Wineries', by F. E. DeMartini, Jr., Sanitary Engineer, State Department of Public Health, Berkeley, California.

THURSDAY—*Noon*

Luncheon at Hotel Maryland.

THURSDAY, SEPTEMBER 6—*Afternoon*

2:00 p. m.—Musicians Locker Room, Civic Auditorium.

Business Meeting. Reports of Committees. Election of Officers. Papers:

1. 'Establishing Insurance Rates for Sewerage Construction Work', by Walter A. Chowen, Manager, California Inspection Rating Bureau.
2. 'The Sewage Disposal Situation in Other States':
 (a) Kansas—By Earnest Boyce, State Sanitary Engineer.
 (b) Arizona—By F. C. Roberts, State Sanitary Engineer.
 (c) Oregon—By Carl Green, State Sanitary Engineer.
 (d) Washington—By Roy M. Harris, State Sanitary Engineer.
3. 'Los Angeles Screenings Incinerator at Hyperion', by F. A. Batty, Superintendent of Sewers, Los Angeles.

MINUTES, SEVENTH ANNUAL CONVENTION, CALIFORNIA SEWAGE WORKS ASSOCIATION

The Seventh Annual Meeting of the Association was held at Pasadena, September 5-6, 1934, at the same time as the meeting of the American Public Health Association.

Many of the members arrived Tuesday night and had the pleasure of attending the Annual Hi-Jinks Dinner of the Public Health Engineering Section, A.P.H.A. Director Alexander Bell presided at the dinner, which was featured by high-class entertainment and short talks by prominent sanitary engineers.

A caravan of about 40 cars took members and guests on the Wednesday trip. On Thursday, after papers were read according to the program, a short business meeting was held.

Reports of committees were read or discussed by the following members:

Membership—F. E. DeMartini.
Legislative—W. T. Knowlton.
(Written reports by C. C. Kennedy and A. K. Warren were read by the Secretary.)
Publicity—Letter from A. G. Darwin, Chairman.
Licensing Operators—T. R. Haseltine.
(Written report submitted by A. C. Beyer, Chairman.)
Safety Regulations—F. D. Bowlus.

These reports and that of the Secretary-Treasurer were accepted.

The Nominating Committee consisting of C. Froerer, J. H. Van Norman and G. Kjellberg presented its report and following additional nominations, the following were declared elected:

President—T. R. Haseltine. (Unanimous.)
First Vice-President—A. M. Rawn. (Unanimous.)
Second Vice-President—E. A. Reinke.
Secretary-Treasurer—F. D. Bowlus.
Director—J. F. Smith.
Board of Control—R. F. Goudey. (Unanimous.)

Mr. Goudey moved and it was seconded and carried that a vote of thanks be given to the retiring officers. President McMillan thanked officers and committees for their hearty cooperation during the past year and particularly the local committee for the Pasadena Convention: W. A. Allen, Chairman; A. P. Banta, M. J. Wesseler, and A. W. Wyman. He then turned the meeting over to the President-elect, T. R. Haseltine, who thanked the members for the honor and promised with the cooperation of the newly elected officers to carry on the work of the Association. The meeting adjourned at 5 p.m.

Respectfully submitted,
E. A. REINKE, Secretary.

EXPERIENCES WITH SEWAGE FARMING IN SOUTHWEST UNITED STATES—TEXAS

By V. M. EHLERS*

Certainly no more appropriate time than the present could be selected for discussing the conservation of water for irrigation, even water from sewage disposal plants, when in many sections of the country crops are suffering from drought. However, in some sections of Texas, droughts are of more or less intermittent occurrence and part of the State is normally arid, hence, the question of placing sewage effluents on land for crop irrigation has long been of interest to Texas engineers who were searching for an economical method of disposing of a city's liquid wastes. One Texas town has been employing land disposal for more than twenty years, another for the past nine years, while still others have used the process for seven, six, four, and two years with good results.

The disposal of sewage on land has come about gradually and naturally as streams became foul during minimum flow periods and land disposal was found to be feasible and economical. There are now 68 towns in Texas using land disposal as a secondary means of sewage disposal, and of these, 34 grow crops, and two use sub-surface irrigation. The chief concern of the sewage engineer has been to dispose of the effluent so as to cause no nuisance, and the value of the waste water as an irrigant has later become apparent. There is a tendency, however, at this time to give more consideration to this means of sewage disposal, as much from a desire to provide water for crop irrigation as to keep water out of streams. The two-fold value of the method adds interest to the problem but also makes the method of disposal more complicated and difficult of successful operation.

A resumé of the data collected by a recent survey of Texas cities reveals some interesting facts concerning this method of sewage treatment of disposal.

Some cities purchase their land, paying from $25 to $125 per acre, and operate the farm. Others lease the city owned land to farmers who get the revenue for taking care of the sewage effluent, while still other cities donate the water to a farmer for his own land, supplying the effluent as the farmer needs it.

The crops most successfully grown on these sewage farms are the small grains, as maize, hegira, kafflr, and corn; the grasses, as sudan, rescue, Johnson grass, and cane; although other crops as cotton and alfalfa have been grown with profit. In addition, orchards of pecan, walnut, grape fruit, and orange trees are profiting by sewage irrigation in some sections of the State. Small truck crops irrigated with sewage have included beans, pumpkins, potatoes, peas and asparagus; while a few cities dispose of their excess activated sludge in the growing of roses, tulips, and other flowers.

* Chief Engineer, State Board of Health, Austin, Texas.

Paper read at Joint Session with Public Health Engineering Section, American Public Health Association, and published with Association approval.

The number of acres used by towns ranges from one to 3500, the total number of acres at present being irrigated for crops in Texas being approximately 4500. The town using only one acre of land employs sub-irrigation. The City of San Antonio has for twenty years discharged its sewage effluent into Lake Mitchell, a holding reservoir, thence to approximately 3500 acres of land which is cultivated to crops. The average city sewage farm, however, is about twenty acres.

The cost to cities of irrigating varies from nothing, where the effluent is donated to a farmer, to $10 per million gallons, assuming no returns on the crops. In many instances the value of the crops has more than paid for the expense of keeping the farm in good condition. Cities operating their own farms have shown a revenue per acre per year of $25 to $135.

The minimum number of gallons of effluent applied per acre per day is shown to be 4500; the maximum, 150,000 gallons per acre per day, but in the latter case the soil is sandy, regularly loosened, has good sub-drainage, and the effluent is applied only at weekly intervals. This virtually means a minimum application of 4500 gallons per acre per day and a maximum of 25,000 gallons per acre per day.

All towns employing land disposal give the sewage some preliminary treatment, usually sedimentation in plain or Imhoff tanks. Several apply filtered effluents although this secondary treatment is not necessary for successful operation. It so happens that a few towns installed filters and later decided to dispose of the effluent on land. About twenty towns use land disposal constantly, while some 48 depend on land disposal only intermittently, as during low stages in the receiving stream or as irrigation water is needed by the co-operating farmer or farm manager.

Land disposal of sewage effluents depends for its successful use upon local conditions such as type of soil, the amount of effluent available, cost of land, climate, and other factors. While the majority of the towns employing this process satisfactorily are located in the arid western part of the State, a few in the southern and eastern portions have used it also with success. Two towns reported the soil too heavy in that particular locality, while one found the salt content of the effluent so high as to impair the soil for successful cropping. Four industrial institutions have found land irrigation a successful method of disposing of wastes from packing houses, cheese factories, and milk plants. The average rate of application for industrial wastes has been found to vary from 5000 gallons per acre per day up to as high as 15,000 gallons where ideal conditions have been present. Where the land has not been overdosed, no nuisances have been reported.

As a guide to our Texas municipalities and designing engineers interested in land disposal of sewage, we have made the following suggestions:

1. Irrigation, with sewage effluents, of vegetables eaten raw will not be permitted at this time.

2. All sewage effluents disposed of on land should have pre-treatment by sedimentation, or other method, to reduce settleable solids by at least 50%.

3. The use of an earthen holding tank or reservoir facilitates application of the liquor but its use is advisable only when located far enough from occupied homes to prevent odor annoyance and where proper maintenance to prevent fly and mosquito breeding nuisances is assured.

4. Adjustment of chemical treatment to avoid injury to soil bacteria and removal of all oils and greases is necessary. Acids and alkalis in the effluent are likely to ruin the fertility of the soil.

5. Care must be exercised in applying a sewage effluent to growing crops, in order to prevent ponding and water-logging of the land. The furrow irrigation is found to be more practical than the border method.

6. Sludge disposal can be successfully effected in some instances by means similar to those employed in broad irrigation.

7. Acreage required for broad irrigation will depend primarily on the soil, both top and sub-soil which must of necessity be porous, as sand, sandy loams, etc. A study of the absorptive capacities is requisite to determination of area required.

8. A study of the water requirements of all possible crops is suggested. The amount of sewage conducive to the growth of one crop may be an "over dose" to another. If utilization of the effluent for crop irrigation is not anticipated, the study will of course be confined to natural existing vegetation.

9. With few exceptions sewage should not be applied to the fields in quantities greater than that absorbed within a period of thirty minutes. Rotation and intervals of application will vary with absorptive characteristics of the soil and the frequency of plowing. Deep plowing (12 inches) at intervals of six to twelve months is recommended. Frequency of shallow plowing will be determined by surface conditions and should be practiced to the extent that top soil will dry out thoroughly. Ponding should be prevented at all times to eliminate potential nuisances.

10. If crops are to be planted, reserve acreage must be provided upon which effluent can be placed during rainy weather and when crops do not require additional moisture.

11. Rainfall, evaporation, and temperature are to be taken into consideration in determining the acreage requirements for land disposal.

EXPERIENCES WITH SEWAGE FARMING IN SOUTHWEST UNITED STATES—ARIZONA

By F. C. ROBERTS Jr.*

A review of the sewage farming situation in Arizona presents many items which have to be omitted due to a lack of reliable information; but with the information available, the subject will be presented as thoroughly as time permits.

The sewage disposal of the city of Tucson was studied from every angle, then by incorporating some material from the city of Casa Grande, a more complete picture was obtained of the sewage farming situation in the southern part of the State of Arizona. This portion of the United States is most arid; this climatic feature has a tremendous influence on farming conditions.

In presenting the picture of sewage farming in Arizona, there

* State Sanitary Engineer, Arizona State Board of Health.

Paper read at Joint Session with Public Health Engineering Section, American Public Health Association, and published with Association approval.

fore, the cities of Tucson and Casa Grande will be generally considered from the viewpoints of operation, economics, and public health.

Sewage Farming in Tucson

The following are pertinent facts about this city:

Population according to the 1930 census	32,506
Average yearly precipitation	11.5"
Average temperature per year	66.0° F.
Average minimum temperature	49.9° F.
Lowest recorded temperature	12.0° F.
Average maximum temperature	82.0° F.
Highest recorded temperature	112° F.
Average sewage flow per day, million gallons	2.5
Average type of sewage is domestic, with small creamery waste.	
Average water consumption per day, million gallons (1922-1933 inclusive)	4.9

The city has a separate sanitary sewerage system that concentrates at the north-west corner of the city. It flows thence by gravity through a 30-in. concrete outfall line to an inverted siphon some 3.1 miles away. After passing through the siphon under the river, the sewage flows through a screening chamber, thence through a sedimentation chamber, with a 30-45 minute retention period and finally out onto the farm. The sludge from the sedimentation chambers is concentrated and automatically pumped into a battery of five uncovered sludge digestors, the overflow from the digestors running back into the sedimentation chambers.

The raw sewage as it reaches the screening chamber has a hydrogen sulphide content at times of approximately six p.p.m., which is not surprising in view of the fact that the inverted siphon has to be cleaned from time to time due to accumulations of solids. There are places of seeding along the outfall line that produce a septic influent to the plant. The plant having only primary sedimentation improves the quality of the effluent only by reducing the suspended and settleable solids in the amount of 79 and 95%, respectively. The suspended solids in the raw sewage average about 300 p.p.m.

The effluent as it discharges onto the farm, is therefore in a septic condition, and odors arising from the farm should not be charged to the farm, nor in the main to the uncovered condition of the digestors at the plant, but rather to the poor condition of the influent.

In the operation of the farm, there are objectionable odor conditions that arise from time to time, although recently there have been few complaints by neighbors. These odor conditions may be kept to a minimum if the following precautions are observed in tilling the soil:

1. Pooling or standing of sewage in the furrows should be completely eliminated, either by plowing, cultivating, or other process.

2. Banks of ditches should not be allowed to become rank with growth so as to catch and retain the solids along the borders. This may be controlled by the use of chemicals, or by keeping the banks constantly spaded.
3. Cross sections of irrigation ditches should be small with a maximum of depth and a minimum of width.
4. Choice of soil is an important item. A sandy loam is to be preferred to other types to preclude possibility of the soil "sealing itself off".
5. The city should operate the farm itself or have administrative power over the management to preclude the possibility of nuisance.

The city of Tucson has protected itself from odor complaints by the purchase of large tracts of land. At the present time the area of the farm comprises 1360 acres, of which they use 200 in summer to dispose of the 2.5 million gallons per day, or 12,500 gallons per acre per day in the hot summer months with the high evaporation available; and 350 acres in winter to dispose of the same amount of sewage, or 7800 gallons per acre in the winter months.

Five men including the superintendent are needed to adequately operate this farm and disposal plant. The crops grown in this particular climate with the yield per acre as accurately as the available information presents are:

1. Barley for hay and grain, one ton of threshed grain and 1½ tons of hay per acre per crop.
2. Corn for use as ensilage, 8½ tons of ensilage per acre.
3. Alfalfa for use as hay, one ton per acre per cutting, and five cuttings per year.
4. Maize either as milo-maize, higuera, or federita, all used as fodder crops, one ton per acre.
5. Sudan grass used for grazing (this practice has been discontinued), and
6. Cotton, one bale per acre.

According to a former farm superintendent, a yield of 25 to 30% greater from sewage irrigated land would be expected than from other irrigated land in that particular locality. Due to the fact that this farm is more or less uneven and has not been completely leveled, the yield is approximately the same as that from adjacent farms.

A few of the economic features are presented below:

Capital investments:	
Cost of the 1360 acres for the farm	$ 64,350
Cost of the disposal plant and accessories	82,600
Cost of various improvements to the farm itself	30,000
Total cost of the system up to the present	$176,950

Operation costs include all outlay, and subtracting all income:

1927-28	$ 7,655.74
1928-29	9,041.18
1929-30	16,468.56
1930-31	22,744.14
1931-32	8,852.89
1932-33	4,324.59
1933-34	3,327.73

The years of high operation cost were those years in which ambitious programs were carried out. It has been discovered that if the farm is operated only as a means of disposing of the sewage, without attempting to produce record crops, and incidentally trying to compete with other farms, greater economy is affected. Crops raised on this farm are but incidental items, revenue from crops helping to offset operation expense. In addition, if this policy is carried out it does not place the city in the embarrassing postion of trying to compete with private enterprise.

1. Harvesting and pen-feeding, seemingly present little danger. The crops that are at present grown on this land are harvested so that they are exposed to a minimum of contamination. The hay that is cut is cut on a dry field. With the amount of curing and exposure to the elements it seems hardly possible that disease might arise from this source.

2. If cattle are grazed on this farm, an entirely different condition arises. To illustrate this point an example of a recent condition will be submitted:

A herd of 45 cattle fattened on this farm were slaughtered and found to have 23 of their number infested with tape worms described as cysti cercus bovis, or measly beef caused by Taenia Saginata. The cattle so slaughtered all bore different brands and were assumed therefore to have come from different ranges. Due to this fact, and also that this particular herd of cattle persisted in drinking effluent from the plant in preference to fresh drinking water, it has been concluded that they contracted their infestation from this common origin.

With the exception of the draft animals grazed on this land and used by the city in its sundry duties, it has been recommended that the practice of raising live stock on this farm be discontinued.

3. The danger from fly borne disease is great from a farm of this kind if the farm is not properly worked. The personnel must watch for and eliminate all places of breeding these insects.

4. The danger of use of this type of broad irrigation to underground water supplies has not been thoroughly investigated up to the present time, although no signs of pollution have been discovered. If this was a more populous region, this might be a considerable problem, but inasmuch as the shallow ground water table is at a depth of at least 30 feet and domestic wells are located a considerable distance from the main body of the farm, this phase is not as important as it might be elsewhere.

Sewage Farming in Casa Grande

As a comparison, the city of Casa Grande will be considered from some of the same viewpoints.

The statistics for this city are:

Population according to the 1930 census	1,351
Average yearly precipitation	6.89 in.
Average yearly temperature	71.7° F.
Average minimum temperature	51.7° F.
Lowest recorded temperature	13.0° F.
Average maximum temperature	87.6° F.
Highest recorded temperature	120 ° F.
Average sewage flow per day	150,000 gal.
Type of sewage is domestic with small creamery wastes.	
Average gross water consumption per day (1933)	238,000 gal.

This city has a separate sewage system that concentrates at the northwest corner of the city. At this point the sewage is treated with chlorine gas and after treatment flows from this point to the point of outfall, 6300 ft. northwest. The outfall is a 12-in. vitrified clay tile pipe.

At the point of outfall the sewage was at one time introduced into a septic tank. But due to the trouble that was caused by trying to irrigate with septic sewage, this was discontinued and for the past three years the raw sewage has been used for irrigation.

Chlorination of the sewage has been experimented with to the point that they may control odors at the sewer farm if a dose of 6-7 parts per million is used, although residual chlorine is not carried in the sewage to a manhole 300 feet away from the point of chlorination. If the dosage of chlorine is increased to 10 to 11 parts per million the residual chlorine will be carried to the point of outfall.

In farming only 25 acres are required to dispose of the sewage, giving a rate of 6000 gallons per acre. The city owns 40 acres of this sandy loam ground, but up to the present has not required the use of more than the 25. The small acreage required on this farm is due principally to the control of odors through chlorination. The only crop raised is cotton. The yield is usually two bales per acre as compared to one bale per acre from the best adjacent farms.

The city does not farm this land itself, but leases it at a rate of $90 for three years. The cost of chlorination is 50c per day, or $183 per year, dosing at the rate of 6-7 parts per million. Therefore, the cost to the city is $153 per year plus supervision to dispose of the 150,000 gallons per day flow.

It takes but one man, furnished by the leasor, to take care of this amount of sewage on this 25-acre tract. Provision is made in the city's contract that only those crops approved by the city government will be grown. The city, therefore, has an administrative power over the land.

Conclusion

In conclusion, it would seem that a combination of these two methods of sewage farming would be satisfactory in this climate providing that industrial wastes do not complicate the problem. With

the ordinary domestic wastes, the system of pre-chlorination with a long contact period, to aid in sterilization and to enable the sewage to reach the land in a fresh condition, coupled with screening and primary sedimentation to relieve the land of some of the load placed on it, would prove economical and satisfactory from every viewpoint, in the system of sewage farming as developed by these two cities.

Appreciation is extended to the following individuals in their co-operation and efforts in discovering information on this subject:

Mr. George W. Marx, City Engineer, Tucson; Mr. R. C. Butler, City Manager, Tucson; Mr. C. E. Pecquignot, Auditor, Tucson; Mr. M. E. Watson, Farm Superintendent (1930-32), Tucson; Mr. Norman, City Engineer, Casa Grande.

EXPERIENCE WITH SEWAGE FARMING IN SOUTH-WEST UNITED STATES—CALIFORNIA

By E. A. REINKE*

Irrigation of crops with sewage has been practiced in California for many years. Pasadena's sewer farm was purchased in 1887 and is probably the oldest in the state.

Early methods of handling sewage were crude. Few treatment plants were in use and there was little or no restriction on crops raised. The tendency then, as now, was to derive the greatest possible revenue from the farm, and regard for sewage disposal was secondary. It naturally followed that dissatisfaction arose, neighbors complained of odors, flooding of adjoining property, and fly and mosquito breeding. In 1900 to 1910, many septic tanks were constructed hoping to overcome the objections, but experience with them was disappointing. Imhoff tanks came on shortly after and gave some improvement. In recent years, both Imhoff tanks and separate sludge digestion plants have been used for preliminary treatment and the trend has been to adopt trickling filters and activated sludge plants for oxidation works, prior to irrigation.

There was a steady increase in use of sewage for irrigation during the thirty-year period from 1890 to 1920. The peak was reached about 1923, when some 70 municipalities disposed of all or part of their sewage by irrigation of crops. Accurate data are not available for the period before 1920, but since that year, 15 places have started irrigation with sewage and 30 others have abandoned the practice. Those abandoning sewage farming have, in the majority of cases, gone into joint outfall sewers, spread the sewage on land without cropping or constructed new disposal works. At the present time, sewage from

* Senior Sanitary Engineer, Bureau of Sanitary Engineering, State Department of Public Health.

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53 municipalities is being disposed of by irrigation of cultivated crops, from 9 others by irrigation of wild crops, and from another 28 on land wth no crops.

Thus 90 out of a total of 310 municipalities in California having sewer systems, now have land disposal.

A survey of use of sewage for irrigation in California was made by the Bureau of Sanitary Engineering in 1933. At that time 62 cities reported use of sewage on land and 46 went in for some kind of cropping, watering a total of 4050 acres. Of this, 3628 acres were under cultivation, the remainder being wild grass. The acreage of various crops irrigated with sewage effluent included 340 acres of vegetables (all of varieties that are eaten cooked), 150 acres of dry beans, 63 acres of tomatoes and 1660 acres of fruit trees and vineyard. The remaining 1617 acres were planted to alfalfa, fodder crops, sugar beets, hops and cotton.

In 1918 the California State Board of Health adopted regulations concerning use of sewage effluents for irrigation, which prohibited irrigation of berries and salad vegetables; permitted irrigation of vegetables harvested in the dry state; and permitted, under restrictions, such uses as: (1) for garden truck if not watered one month before harvesting; (2) orchards, if windfalls were not gathered for human consumption; (3) melons if raised on hills above the water, and (4) fodder crops if milk cows were excluded from the fields.

Under the regulations, health officials were obviously required to supervise the growers and the regulations proved unsatisfactory.

In recent years, with increasing population, shrinkage of water supplies and improved methods of sewage treatment, several groups urged wider use of sewage effluents for irrigation which could not be done under the then existing regulations.

Under all the circumstances a revision of the regulations seemed advisable, and after a series of conferences with health officers and sewage disposal experts, new regulations were decided upon and adopted in May, 1933, based on classification of sewage effluents as well as on crops to be irrigated.

The aim was to minimize the supervision of the growers by health departments and, instead, to concentrate efforts on operation of the sewage treatment plants and the character of effluent produced.

In brief, the present rules forbid the use of raw sewage and raw or undigested sludge for irrigation of growing crops; make no restrictions on use of well oxidized, highly disinfected effluents; and permit the use of settled and undisinfected effluents on nursery and fodder crops, cotton and sugar beets, but not on vegetables, berries and low-growing fruits.

Since sewage irrigation is considered an integral part of sewage disposal, the intention is that its regulation in Calfornia be handled under the permit features of the Publc Health Act. This Act governs all forms of sewage disposal.

TREATMENT AND DISPOSAL OF SEWAGE IN THE NATIONAL PARKS

By H. B. HOMMON*

Since 1921, sanitary engineers of the U. S. Public Health Service have been detailed to the National Park Service to assist superintendents of national parks, custodians of national monuments, and engineers of the Park Service on problems of sanitation in the parks and monuments. The work of the sanitary engineers has included surveys and reports of investigations of water supplies, sewerage and sewage disposal, garbage disposal, swimming pools, mosquito control and general inspections of all places handling and serving food products. In addition to the surveys, reports and general inspections, plans have been prepared for water supply systems, sewage treatment plants and garbage incinerators.

The sewage treatment plants which will be discussed in this paper have been constructed in the parks in the Western Division of the National Park Service. In this Division, which includes the National Parks west of the Mississippi River, except Hot Springs National Park, Arkansas, there are 19 parks whch are located in the following states and territories: One in Alaska, one in Arizona, four in California, two in Colorado, one in the Hawaiian Islands, one in Montana, one in New Mexico, one in Oregon, one in Oklahoma, one in South Dakota, two in Utah, one in Washington, and two in Wyoming. All these parks, except Hawaii, are located in sections of the country or at elevations where there are more or less severe winters. Some of the parks are practically inaccessible in the winter, others are visited by parties on snow shoes or skis, and ten, which include Carlsbad Caverns, General Grant, Grand Canyon (South Rim), Hawaii, Mount Rainier, Platte, Rocky Mountain, Sequoia, Yosemite and Zion, are open to tourists by train or automobile throughout the year.

In 1933, the number of people who visited the western parks was 2,013,024. The maximum number visiting one park was 296,088 at Yosemite, and the smallest number was 368 at Mount McKinley. The parks having over one hundred thousand visitors were as follows: Yosemite, 296,088; Rocky Mountain, 291,934; Hawaii, 237,690; Platt, 220,606; Mount Rainier, 170,104; Yellowstone, 161,938; Sequoia, 126,-464; and Grand Canyon, 105,475. There are in addition to the visitors in the various parks, a permanent population which varies from a comparatively few in the smaller and less patronized parks, to a maximum of approximately 1500 in Yellowstone.

The accommodations for visitors in the parks are hotels, lodges, housekeeping cabins and automobile camp grounds, and for the permanent population residences and dormitories. The locations of these

* Sanitary Engineer, U. S. Public Health Service, in Charge Sanitation in National Parks in the Western Division of the National Park Service.

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accommodations in the various parks vary widely. At the South Rim of the Grand Canyon practically all the visitors and employees live in one area, whereas in Yellowstone there is one area with all the accommodations listed above, four with all the accommodations except residences, two other places with lodges, housekeeping cabins and large camp grounds, and several other smaller areas having automobile camps. The maximum number of people in one area in a park was 23,000 in Yosemite Valley on July 4, 1932. In Yellowstone there are six areas where the total population will vary from 100 to 2500 people, and other places, mostly automobile camps, where the number of tourists will range from 25 to 100. In Yosemite Valley there were at one time 9000 visitors living in tents in tourist camps, and in Yellowstone 800 in each of two camps.

There are in the western parks, 65 acres having for visitors extensive accommodations which are generally grouped together and served by a common water supply system, sewerage system and disposal plant, garbage incinerator and other public utilities.

There have been constructed in the western national parks 52 sewage treatment plants since 1922. In designing these plants the important considerations were: (1) protection of streams against contamination and in one park reclamation of sewage for industrial purposes; (2) prevention of odor nuisances; and (3) maintaining architectural and landscape values. The treatment plants constructed include: (a) activated sludge, rapid sand filter and disinfection; (b) activated sludge and disinfection; (c) settling tanks and disinfection; (d) settling tanks and spraying systems which distribute settled sewage, with and without disinfection, over natural ground surfaces, usually hillsides of porous material; (e) settling tanks and subsurface galleries with concrete, wood, or metal walls and covers; (f) settling tank and glass-covered sand filter; (g) settling tanks and open trenches; and (h) settling tanks, broad irrigation, ponds and disinfection. In the following paragraphs are given descriptions of a representative plant of each of the types listed above.

Activated Sludge, Rapid Sand Filter and Disinfection

The cost of hauling water to the South Rim of the Grand Canyon National Park in tank cars and delivering it in service lines, prior to 1932, was $3.07 per 1000 gallons and approximately $2.50 for pumping and delivery since that date. In order to reduce the volume of water hauled to the Canyon, a pressure sand filter was added in 1913 to an existing sewage treatment plant, consisting of septic tank and contact filter, to produce an effluent which could be used in place of fresh water for irrigation of lawns and making steam in boilers. For a few years following 1913 the effluent was apparently satisfactory for the purposes noted above, but with an increasing volume of sewage the plant became badly overloaded, a serious odor nuisance

developed, and the effluent could not be used on lawns because of the odors, or in boilers due to foaming.

It was decided in 1926 to build a new sewage treatment plant to produce an effluent which could be used for industrial purposes and could be distributed in a separate piping system properly protected against cross-connections, without being a serious health hazard to the visitors and people living at the South Rim.

A treatment plant consisting of settling tank, slow sand filters and disinfection seemed to have the most inherent advantages from the standpoint of high removal of bacteria and quality of effluent in general, and low cost of operation and maintenance, but it was impracticable to build this type of plant on account of the high cost of sand delivered to the South Rim. The treatment plant designed included activated sludge, rapid sand filters and disinfection. (1, 2.) The local conditions, other than those pertaining to the industrial uses of the reclaimed sewage, which had to be given consideration in the design of the treatment plant were the variations in the temperature of the raw sewage, which ranged from 92° F. in the summer to 72° F. in the winter, and the treatment of the laundry wastes which constitute approximately 10% of the total volume of sewage. Figure 1 shows a general view of the treatment plant.

The available data indicated that the maximum volume of sewage produced at the Canyon during 1926 was 100,000 gal. per day, and

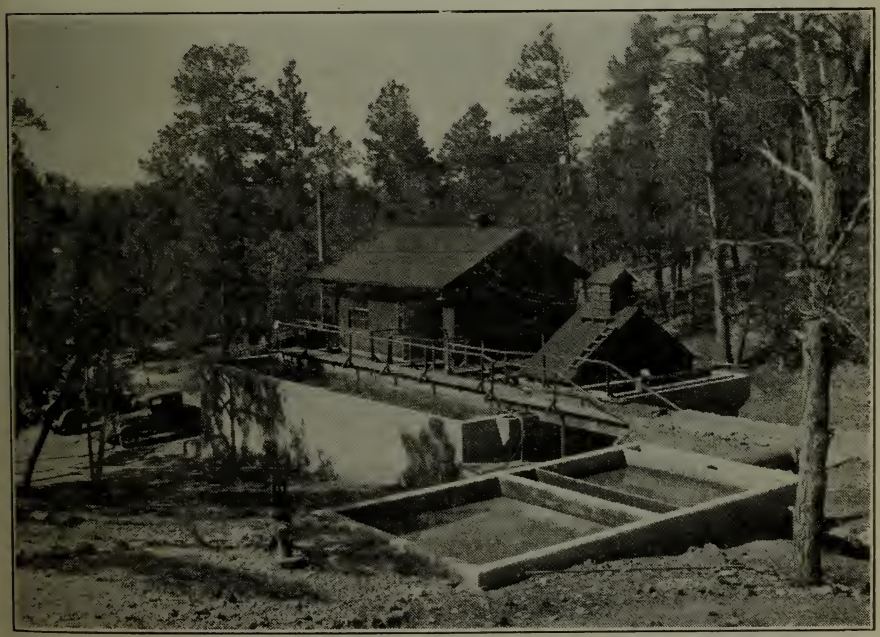


Fig. 1—*Sewage Treatment Plant, Grand Canyon National Park.*

the treatment plant was designed to treat 200,000 gal. The following devices were included in the plant:

SCREEN—2-in. bar screen 3 ft. wide by 3 ft. deep.

PRESETTLING TANK—16 ft. long, 8 ft. wide and 9 ft. deep to bottom of two hoppers 4 ft. deep. Detention period, 30 min. for 200,000 gal. per day.

DIVERSION CHAMBER—Small tank for return activated sludge or for bypassing sewage.

AERATION TANKS—There are two of these tanks, each 42 ft. by 8 ft. by 10 ft. deep below the water level. They were designed for an average aeration priod of six hours.

In each tank there are two continuous concrete channels each 42 ft. long and having at the top porous plates which rest on T-irons across the channels and in recesses along the sides of the channels, and which are held in place by cement grout. There are concrete ridges between the channels. The air is pumped through 4-in. pipes to one end of the channels and at the opposite end there are 4-in. outlet pipes which permit flushing of the channels and cleaning the under surfaces of the porous plates with water or steam. The tanks were designed so that they can be operated in series or separately.

CLARIFIER—16 ft. square, 11.5 ft. effective depth; settling rate, 800 gal. per sq. ft. per day and 2-hr. detention period for 200,000 gal. per day.

COAGULATION TANK—16 ft. by 4 ft. by 10 ft. deep. No coagulant needed; acts as secondary settler.

RAPID SAND FILTERS—There are two of these filters each having an area of 77 sq. ft. The wash-water troughs are of concrete and the underdrainage consists of 12-in. headers with 1¼-in. cast iron laterals having ¼-in. holes bored on 3-in. centers. Each filter has 20 in. of graded gravel and 32 in. of sand with an effective size of 0.40 millimeters and a uniformity coefficient of 1.6. Reclaimed sewage, disinfected, is used for washing the filters.

DISINFECTING EQUIPMENT—Duplicate semi-automatic chlorine machines are used for disinfecting the effluent from the sand filters.

BLOWERS—Two blowers each with a capacity of 225 cu. ft. of free air per min. against 5.6 lbs. pressure per sq. in. at an altitude of 6500 ft., supply the aeration tanks and air lift with air.

WASH-WATER STORAGE TANK—This tank, which is used to store the wash water from the filters, is 25 ft. long by 16 ft. wide and 4.5 ft. deep below the overflow. A small centrifugal pump returns the wash water to the presettling tank.

PUMPING EQUIPMENT—The final effluent from the plant is pumped through 1½ miles of 4-in. pipe to a 200,000-gal. elevated tank by two 3-stage centrifugal pumps.

B.COLI IN EFFLUENT—Laboratory findings on 530 samples collected from 1929 to 1933 inclusive showed a maximum of 6.4% of 10 cc. portions positive.

In Tables 1 and 2 are given, respectively, the monthly averages of chemical analyses, and data pertaining to the operation of the treament plant for 1933 and up to August, 1934.

Handling reclaimed sewage—All the pipe lines carrying reclaimed sewage are enclosed in vitrified pipe and all pipes in buildings or above ground are painted red, and over every service outlet there is a sign warning against drinking the water. The tank in which the reclaimed sewage is stored is 125 ft. lower than the tank used for domestic water. Accurate maps of the two water systems are kept up to date. Beginning in October this year a dye solution strong enough to give a color to the reclaimed sewage will be added once a month to the effluent at the treatment plant.

TABLE 1—CHEMICAL ANALYSES OF RAW AND RECLAIMED SEWAGE
GRAND CANYON NATIONAL PARK

Month 1933-1934	Suspended matter p.p.m.			Settleable solid c.c. per liter 1 hour		Dissolved oxygen p.p.m.		Oxygen demand p.p.m.			Soap hardness p.p.m.		Hydrogen in concentration		
	R	C	C.W.	R	C	C.W.	P.H.	C	C.W.	P.H.	R	C.W.	R.C.	C	C.W.
January	104	10.0	0.3	8	0.3	7.3	8.2	6.8	1.8	1.5	21.0	14.8	7.6	7.2	7.5
February	74	10.0	0.3	6	0.25	7.4	8.5	7.3	1.6	1.4	25.0	16.6	7.5	7.2	7.4
March	111	9.0	0.3	9	0.24	7.3	8.3	7.2	1.3	1.3	21.7	17.7	7.5	7.1	7.3
April	91	10.0	0.3	7	0.28	7.0	8.0	6.8	1.3	1.2	21.3	19.2	7.5	7.2	7.4
May	103	11.0	0.3	8	0.29	6.7	7.3	6.3	1.6	1.6	20.0	20.8	7.5	7.2	7.4
June	163	9.0	0.3	10	0.24	5.6	6.0	5.3	1.3	1.4	22.7	15.9	7.5	7.2	7.3
July	105	11.0	0.3	8	0.3	4.5	5.2	4.3	2.5	1.8	20.9	17.5	7.6	7.2	7.3
August	120	12.0	0.3	10	0.3	4.4	5.0	3.8	1.3	0.9	23.2	18.4	7.5	7.3	7.4
September	105	8.0	0.27	8.2	0.2	4.6	5.8	4.4	1.3	1.3	19.0	16.5	7.5	7.3	7.4
October	86	11.0	0.3	7	0.27	5.2	5.7	4.9	2.0	1.4	17.3	16.0	7.5	7.3	7.4
November	93	9.0	0.3	7	0.2	5.0	5.5	4.6	1.7	1.2	19.0	14.2	7.5	7.2	7.4
December	90	10.0	0.3	7	0.27	5.2	5.8	5.0	1.7	1.2	20.8	19.1	7.5	7.2	7.4
January	88	10.0	0.25	7	0.26	5.3	5.6	5.1	1.3	1.1	20.9	16.9	7.5	7.2	7.4
February	101	10.6	0.18	8.3	0.31	5.3	5.5	5.1	1.6	1.6	20.5	17.0	7.5	7.3	7.5
March	89	9.7	0.17	7.4	0.24	5.3	5.8	4.1	2.5	1.4	22.8	14.0	7.6	7.3	7.4
April	94	11.2	0.18	7.8	0.28	4.2	4.9	4.2	2.6	1.8	21.5	15.3	7.6	7.2	7.5
May	92	9.6	0.11	7.6	0.24	4.6	5.2	4.6	2.2	1.7	20.5	19.2	7.7	7.1	7.4
June	97	12.5	0.1	8.1	0.2	3.6	4.3	3.6	2.9	2.1	22.6	21.1	7.6	7.2	7.4
July	88	14.0	0.1	7.4	0.35	2.7	3.2	2.6	1.8	1.7	23.8	20.3	7.6	7.2	7.5

NOTE: R — Raw sewage.
C — Effluent clarifier.
C.W. — Clear well.
P.H. — Tap at make-up tank in power house.

TABLE 2—OPERATING DATA, SEWAGE TREATMENT PLANT, GRAND CANYON NATIONAL PARK
(Figures represent monthly averages of daily records)

Month 1933 - 1934	Sewage flow thousand gallons daily	Reclaimed sewage thousand gallons daily	Temp. deg. F.		Sludge wasted thousand gallons		Aeration Tanks			Sand Filters		Chlorine		
			Raw	Effl.	Raw	Active	Percent sludge in tanks	Aeration hours	Cubic feet* air used per gal.	Rate† of filtration M.G.A.D.	Percent wash water	lbs.	p.p.m.	Resid. p.p.m.
January	76	75	70	62	0.6	0.2	23	10.2	4.0	23	6.7	2.7	5.6	0.8
February	68	67	70	61	0.6	0.3	25	10.3	4.4	21	7.4	3.1	6.0	0.8
March	69	68	76	66	0.6	0.3	24	10	4.3	21	7.3	3.7	6.7	
April	93	92	78	66	0.6	0.3	24	10	3.3	28	5.6	3.6	6.0	0.8
May	102	101	80	67	0.6	0.5	25	9.2	3.0	31	5.1	4.1	4.8	0.8
June	103	102	74	82	0.6	0.6	25	8.9	3.0	31	5.0	3.8	4.5	
July	105	104	86	78	0.6	0.4	24	8.8	2.9	32	6.2	4.6	6.0	1.0
August	112	103	84	78	0.6	0.8	25	8.7	2.7	34	5.8	5	5.9	0.8
September	108	107	84	77	0.6	0.6	25	8.5	2.8	33	6.0	4.6	6	0.8
October	103	102	82	75	0.6	0.7	26	8.9	2.9	31	6.3	4.8	6.1	0.8
November	96	94	79	71	0.6	0.6	24	9.6	3.1	29	6.8	4.5	6.4	0.8
December	99	97	75	68	0.6	0.5	25	9.2	3.1	30	6.5	4.5	4.6	0.8
January	95	92	68	75	0.6	0.4	24	10	3.2	29	6.8	4.6	5	0.8
February	96	92	84	72	0.6	0.7	25	9.9	3.3	29	6.8	5.3	6.5	0.8
March	101	100	72	79	0.6	0.8	21	9.7	3	31	6.4	4.9	7	0.7
April	109	107	85	77	0.6	1.2	29	8.1	2.8	33	5.9	7.4	6.9	.44
May	105	103	86	78	0.6	1.6	26	8.7	2.9	32	6.2	5.2	5.1	.52
June	112	110	89	80	0.6	1.0	27	8.2	2.7	34	5.8	5.6	6	.43
July	110	109	93	86	0.6	0.8	27	8.3	2.8	33	5.9	6.1	6.7	.46

* Air supplied at a uniform rate of 225 c.f.m. No deduction for air lift.
† Average rates; maximum rates are approximately twice the averages.

Uses of reclaimed sewage—The reclaimed sewage is used in locomotive boilers, boilers for heating purposes, for watering lawns and flowers at the El Tovar Hotel, for flushing toilets in public comfort stations, washing automobiles, cooling water in jackets of Diesel engines, and in pipes used for drying garbage in an incinerator.

Cost of reclaiming sewage—The cost of operating the treatment plant, exclusive of interest and depreciation, but including pumping the reclaimed sewage to the storage tank, averages approximately $0.38 per 1000 gal.

Activated Sludge and Disinfection

In 1930 there was constructed in Yosemite Valley, in Yosemite National Park, an activated sludge plant to replace an Imhoff tank and natural sand filters which were badly overloaded and producing offensive odors. Yosemite Valley, at the only place where a new sewage treatment plant could be located, is approximately one mile in width with vertical walls about 3000 feet in height, and there are two highways, one on each side of the river which flows through the middle of the valley. On account of the odor nuisance and bad appearance of the old treatment plant, and the unfavorable topography of the floor of the Valley, with regard to suitable sites for a new plant, local sentiment in the Valley was doubtful that any type of treatment plant would operate without some kind of nuisance. The stringent requirements which the new plant had to meet were: (a) that there would be no odors; (b) that the plant could not be seen from the highways on the floor of the Valley or on slopes leading out of the Valley; (c) that there would be no noise; (d) that the Merced River, which is used as a source of domestic water supply, would not be contaminated, and (e) that fish in the river would not be killed by chlorine in the effluent from the plant.

The treatment plant was designed to treat a maximum of 1,200,000 gal. of sewage daily, which was approximately two times the maximum flow up to 1930. Practically all of the sewage is pumped to the plant at a rate of 850 gal. per min., which, while the pumps are operating, gives a rate of flow of 1,200,000 gal. through the plant.

The plant has the following treatment devices and equipment:

COARSE SCREENS—The screen chamber, which is 7.5 ft. by 5 ft. by 2 ft. deep below the outlet, has two bar screens, one with 2-in. and the other with 3-in. openings. The screens were designed primarily to remove coarse material which might clog the 12-in. siphon which begins at the screen chamber and extends under the river to the presettling tank.

PRESETTLING TANK—This tank is 40 ft. by 10 ft. by 16 ft. deep to the bottom of the hoppers, and has a concrete cover. The theoretical detention period is 45 min. when treating 850 gal. per min., which is the capacity of the pump normally used to lift the sewage to the gravity line to the treatment plant. There is a baffle at the inlet but only a skimming weir at the outlet. The sludge is drawn from the hoppers to the thickening tank daily during the period of maximum travel to the park.

AERATION TANKS—There are four aeration tanks of the Manchester type,

each 50 ft. by 18.5 ft. and 12 ft. effective depth. There are in each tank, two rows of porous plates set over continuous channels extending the length of the tanks. The plates were set in recesses along the sides of the channels and on flat aluminum bars across the channels. Cement grout was used to hold the plates in place and make airtight joints. Air is applied at one end of the channels and at the opposite ends there are outlets for flushing the channels and washing the under surfaces of the plates. Tanks 1 and 2 are arranged for operation as single units, in series or in parallel, and tanks 3 and 4 in series with 1 and 2. The tanks were designed for a theoretical aeration period of 5.5 hr. with 20% activated sludge.

FINAL CLARIFIERS—The two clarifiers, each 28 ft. square at the top and with circular bottoms, have 11 ft. and 10 ft. effective depths, respectively, and are operated in series. Each tank was designed for a settling rate of 1600 gal. sewage per sq. ft. per day and has an inlet baffle 5.5 ft. deep. Sludge is drawn by air lifts from the first unit to the aeration tanks and from the second unit to the presettling tank. Liquid chlorine is applied to the influent to the second clarifier by full automatic chlorinators in duplicate.

THICKENING TANK—This tank is 12 ft. by 13 ft. by 13 ft. deep to the hopper bottom. Sludge is discharged into this tank by gravity from the presettling tank and the first clarifier. The concentrated sludge is pumped to the digestion tanks and the decanted liquor to the presettling tank.

DIGESTION TANKS—There are four covered sludge digestion tanks, three of which are 28 ft. by 12 ft. by 18.5 ft. deep to the bottom of the hoppers, and the fourth, 13 ft. by 12 ft. by 18.5 ft. There are concrete domes for collecting gas, coils around the walls for heating the sludge, and a pump for delivering sludge to the tanks and for circulating the sludge. Digested sludge flows by gravity to the sludge drying bed.

SLUDGE DRYING BEDS—The glass-covered sludge drying bed is divided into five sections, each 15 ft. by 40 ft., and has one foot of river sand with underdrainage connected to a pipe line leading to a pump sump.

DRAINAGE SUMP—The waste liquors from the digestion and thickening tank, drainage from sludge beds, the wastes from the laboratory and toilets, and all other liquid wastes from the plant, other than the disinfected effluent, are discharged into the drainage sump and pumped to the presettling tank.

BLOWERS—There are two centrifugal blowers, each with a capacity of 425 cu. ft. free air per min. against a head of 7 lb. at an elevation of 3000 feet.

Operation of treatment plant—The plant is under the direct supervision of two operators between 8 a.m. and 2 a.m., with no one at the plant from 2 a.m. to 8 a.m. In addition to operating the treatment plant, the operators inspect and keep in working order the ventilating apparatus at the Wawona Tunnel, and one of the operators makes the chemical analyses of sewage and bacteriological analyses of samples from the effluent of the plant and water and milk collected at various places in the park. Three samples of the effluent and three from the Merced River above and below the outlet of the plant are shipped to the U. S. Public Health Service Laboratory in San Francisco each week for bacteriological analysis. The treatment plant has been in continuous operation since August, 1931, and except for bulking of sludge in the aeration tanks at infrequent intervals and minor troubles with the mechanical equipment, it has operated in a highly satisfactory manner. Figure 2 shows the laboratory and office building and glass-covered sludge bed. Determinations of B.coli in the effluent of the treatment plant and in the Merced River above and below the outlet from the plant during the period 1932-1934 show

the effluent to be uniformly better than the River with 2.3 to 23% of 10 cc. portions positive.

On account of the many duties each operator has to perform at the treatment plant during his shift, it is necessary to limit the chemical analyses to those essential to the operation of the plant and to a knowledge of the character of the effluent discharged to the river. The following table gives operating data and the chemical analyses, except the suspended matter in the raw sewage, which is determined only occasionally in composite samples collected on Sunday, which is the day of the week ordinarily with the heaviest travel to the park. The suspended matter in the sewage produced on Sundays averages between 100 and 125 parts per million.



Fig. 2—*Laboratory and Office Building and Glass-covered Sludge Bed.*

Settling Tanks and Disinfection

Settling tanks with disinfection of the effluent have been used for treating sewage at places in the parks where large rivers or lakes, which are not used as sources of domestic water supplies, are available for receiving the sewage. This type of plant is used at seven places in Yellowstone Park where there are large hotels, lodges and camp grounds. The design of the settling tank used is shown in Figure 3.

TABLE 3—OPERATING DATA AND CHEMICAL ANALYSES, SEWAGE TREATMENT PLANT YOSEMITE NATIONAL PARK

Month 1933 - 1934	Sewage flow thousand gallons daily	Aeration Tanks				D.O. final effluent	B.O.D. Effluent Clariifers p.p.m.		Sludge Digestion Tanks		Chlorine		
		Cu. ft. air per gallon sewage	Percent sett'e-ab'e solids	Percent Suspended Solids	pH effluent		First	Second	pH	Temp. deg. F.	Lbs. per day	p.p.m.	Resid. p.p.m.
January	73	10	18	0.22	6.5	9.4	6.6	0.6	7.1	63	19	31	1.9
February	62	8.7	23	0.24	6.5	10.9	4.2	1.4	7.1	58	9.3	18	1.8
March	84	5.8	24	0.19	6.8	10.5	4.3	2.1	7.2	59	9.0	13	1.8
April	207	2.6	21	0.19	6.2	9.7	4.3	2.0	7.2	65	12	6.9	2.0
May	272	1.7	20	0.19	6.3	9.1	3.8	1.0	7.2	67	16	7.1	2.1
June	661	1.7	19	0.21	6.1	6.3	5.1	2.0	7.1	64	40	7.3	1.8
July	665	1.9	20	0.23	6.0	4.3		1.3	7.1	66	65	12	1.8
August	540	2.7	23	0.21	5.9	6.1	4.4	0.9	7.4	75	39	12	2.0
September	363	2.0	23	0.22	6.2	6.5	4.6	0.9	7.3	75	24	7.9	2.3
October	233	3.1		0.17	6.3		5.8		7.3	84	12	6.3	2.1
November	164	4.1	12	0.10	6.6	8.7	5.2	1.3	7.2	80	10	7.3	2.7
December	161	3.3	11	0.12	6.4	8.9	4.9	1.1	7.3	73	8.6	6.4	1.8
January	186	3.3	11	0.11	5.8	8.7	5.7	0.9	7.2	71	13	8.4	
February	189	3.3	12	0.11	5.9	9.0	6.0	1.4	7.2	72	12	7.8	
March	254	2.4	9.5	0.08	6.1	9.4	5.7	1.4	7.4	68	12	5.5	
April	360	1.5	11	0.10	6.2	8.3	6.5	1.4	7.3	75	15	5.1	2.1
May	537	1.7	8.7	0.11	6.0	7.2	6.8	1.8	7.4	75	33	7.3	
June	645	1.9	13	0.13	5.8	6.2	5.7	1.2	7.1	70	72	13	2.4

NOTE: Figures in table represent averages of daily records.

A uniform amount of chlorine, which is sufficient to disinfect the sewage at the maximum rate of flow, is added continuously to the effluent of a settling tank as it is discharged through vitrified pipe to the bottom of a contact tank which has a detention period of approximately 15 minutes at the time of maximum flow of sewage through the tank.

An inspector visits these plants daily to test the effluent for free chlorine and adjust the chlorine dosage. In adjusting the flow of chlorine to the maximum rate of flow of sewage, there is a fairly high chlorine residual during the night, but it has never had any effect on fish in the streams receiving the sewage. An attempt is made to maintain a chlorine residual of not less than .5 p.p.m. at all times.

In the fall of the year all the sludge is either drawn off from the tanks by gravity to prepared sludge beds, or it is pumped out by

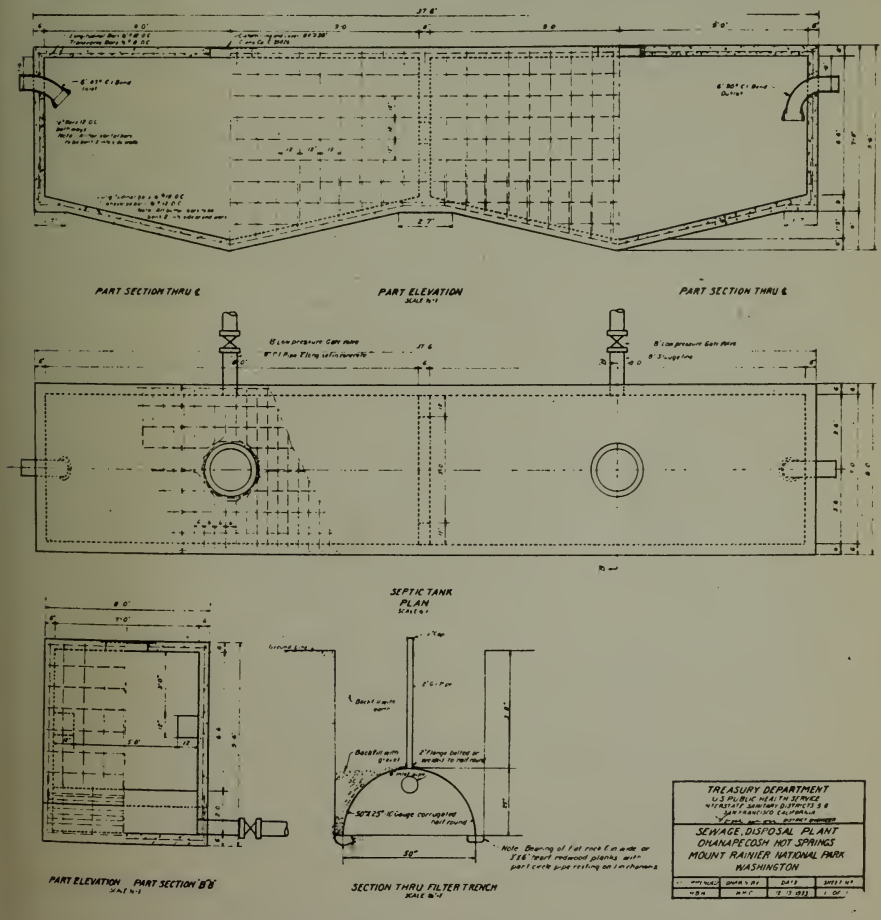


Fig. 3—*Settling Tank Design.*

portable gas engine-driven diaphragm pumps and the tanks emptied and cleaned.

Settling Tanks and Spraying Systems

In many of the national parks there are hotels, lodges and tourist camps located in places, usually in the mountains, where the topography of the ground and other local conditions are unfavorable for the location, construction and operation of the more common types of sewage treatment or disposal plants and where it is much less expensive and often more satisfactory in many ways, to treat the sewage in settling tanks and spray the effluent, disinfected when advisable, over natural ground surfaces, usually hillsides of porous material and covered with vegetation. This method of sewage disposal is generally used at areas in the parks which are open to visitors only during the warmer seasons of the year, and when there is little rainfall. There are ten of these plants in the parks, with disinfection of the effluent at three. Typical examples of this type of treatment plant are at Giant Forest and Lodgepole Camp in Sequoia National Park.

At Giant Forest, with a population of approximately 1000 during the summer, the sewage is treated in a settling tank and the effluent applied by a siphon to sprays which are set in a pipe line approximately 800 ft. long and operate under a head of approximately 50 ft. Below the sprays there is a heavy growth of trees and shrubbery and the soil for a depth of two feet is porous. The spraying system is located where the drainage area above is small and where the nearest stream below is approximately one mile away. The loose material and the vegetation absorb practically all of the effluent and no sewage has ever been found flowing over the ground at a distance of more than 500 feet below the sprays. This plant has been operated during the summer and fall months for seven years. There is a slight odor of fresh sewage at the settling tank and where the sewage is sprayed over the hillside, but it cannot be detected 100 feet from the disposal plant. The absence of an odor nuisance at this plant, and at most of the plants in the parks, is due no doubt to the fact that the sewage is unusually fresh when reaching the treatment plants and that there is very little decomposition in the settling tanks.

At the Lodgepole Camp the sewage from an automobile tourist camp with a population of approximately 300, and a government utility area with 25 employees, is treated in a settling tank and the effluent, disinfected with chlorine, is applied by alternating siphons to sprays set on two separate pipe lines each 300 ft. long and approximately 15 ft. below the siphons. At this place there are trees and shrubbery below the sprays and the soil is sandy and loose. The effluent is disinfected to protect a stream which receives drainage from the area where the sewage is sprayed.

The areas used for the spraying systems at the different plants are selected where there is little drainage above and where the sewage will be sprayed over ground having no well-defined depressions or channels. Whenever the sewage begins to flow in channels the adjacent sprays are closed and the ground allowed to dry, and the soil raked.

Settling Tanks and Subsurface Galleries

In many areas in the parks where there are accommodations for a comparatively small number of visitors and where it is advisable for

various reasons to have the sewage disposal system entirely below the surface of the ground, settling tanks and subsurface galleries are used. In these areas careful investigations are made to find suitable porous material, such as gravel or coarse sand.

The settling tanks, which are used from four to six months in the year, are cleaned each fall. These tanks are designed for a capacity equal to the largest volume of sewage produced daily with approximately an additional one-third capacity for storage of sludge. All the settling tanks which have been constructed in the parks have been designed on the above basis, and all of them are cleaned once a year. The filter galleries are open at the bottom and the covers consist of either concrete, redwood, or half-round corrugated galvanized iron. The half-round culvert pipe can be obtained in diameters ranging from 8 to 86 inches. The length and width of gallery used in any particular case depends on the volume of sewage treated and the character of the subsoil. A typical disposal plant of this type was constructed at Zion National Park to take care of the sewage from the headquarters area, housekeeping cabins and automobile camp. In this area the only available site for a disposal plant is near the cabins, camp and grounds used by visitors, and it was not advisable to have a sewage disposal plant above the ground.

A design of a typical settling tank and subsurface gallery is shown in Figure 3. The effluent from the tank is piped to a diversion box from which it is discharged into three subsurface galleries each 100 ft. in length and 5 ft. dia. The subsoil is loose gravel and rock. The tank is covered with 2 ft. of earth and the galleries are 5 ft. below the surface of the ground.

There are 14 disposal plants of this type in the parks and all of them are operating satisfactorily. The main considerations which govern the successful operation of this type of plant are adequate storage for sludge and low settling rate in the settling tanks, porous subsoil, and sufficient area in the galleries.

Settling Tanks and Glass-Covered Sand Filter

On account of unfavorable local conditions, particularly limited space, impervious subsoil and winter temperatures as low as —35° F., a septic tank and a covered intermittent slow sand filter, divided into two beds, were constructed in 1926 to dispose of the sewage from approximately 50 employees and their families in the summer and 30 in the winter, at the government utility area in Rocky Mountain National Park. The roof over the sand filter consists of wood with glass on the side exposed to the sun in winter. A general view of the sand filter is shown in Figure 4.

The effluent from the septic tank is applied to the sand filter by an automatic siphon. No difficulties have been experienced in operating the filter in the winter with temperatures below zero for weeks at a time.

Settling Tanks and Open Trenches

Settling tanks and open trenches in porous soil have been found a practical method of sewage disposal in several places in the parks,

particularly where there is a comparatively small volume of sewage produced and trenches can be dug in porous soil in areas not frequented by visitors and where other methods of disposal are not practicable. The trenches are usually 2 ft. in depth and 2 ft. wide at the bottom, and at intervals of 100 ft. there are dykes across the trench with pipes connecting the different sections. Disposal plants of this type are operated only during the summer season. A dense growth of algae develops in the sewage in the trenches and there are no odors noticeable 50 feet away. Each spring about ½ inch of surface material is removed from the trenches. This method of disposal is inexpensive and, where local conditions are favorable, it is a very satisfactory method of getting rid of sewage without danger of contaminating streams.

Settling Tanks, Broad Irrigation, Ponds and Disinfection

At the Mammoth Hot Springs area in Yellowstone Park there are housekeeping cabins, hotel, lodge, automobile tourist camp, general stores, with a permanent population consisting of employees of the Government and public operators. This area is adjacent to the Gardiner River, which is the emergency source of water supply for the town of Gardiner, located on the river about six miles below the headquarters area. The population of the Mammoth Hot Springs area during the summer is approximately 1250, and the permanent population during the winter averages about 125.

Two different methods of sewage disposal were considered for the Mammoth Hot Springs area. One included settling tanks, sprinkling filters and disinfection of the final effluent which would be discharged into the Gardiner River, and the other included a settling tank and disinfection of the effluent which would be disposed of by broad irrigation, ponding and disinfection of whatever sewage might overflow from the ponds. The latter method was adopted since it offered a greater measure of protection of the river against contamination, and the topography of the ground was favorable for this method of disposal. The component parts of the disposal system include settling tank, three chlorinators, broad irrigation and ponds. One of the chlorinators is located at the headquarters area and is used to disinfect the small volume of raw sewage produced during the winter when the disposal plant is inaccessible on account of deep snow, and the other two, one of which is used to disinfect the effluent from the settling tank and the other the overflow from the ponds, are operated during the summer and fall.

The effluent from the settling tank, during the time when the park is open to visitors and a large volume of sewage is produced, is discharged into open ditches which carry the sewage to the areas used for broad irrigation and to the ponds. During the winter the effluent from the settling tank does not overflow the ditches and ponds and broad irrigation is not necessary. A small amount of sewage which flows out of the ponds during the summer is discharged onto a sand bar and no doubt eventually reaches the river, but since it has been treated twice with chlorine and stored several days in ponds it is not believed the small amount of overflow from the ponds seriously contaminates the river water. An inspector visits the disposal system daily to adjust the flow of chlorine and regulate the flow of sewage to the areas under irrigation and to the ponds.

There is a slight odor of fresh sewage at the settling tank and a swampy odor near the ponds.

A few bacteriological analyses of samples collected during the summer from

the overflow from the ponds before final disinfection showed that the B.coli group of organisms were present only occasionally in 1 cc. portions.

This disposal plant was inexpensive to construct, costs only a small amount to supervise and maintain, and has produced very satisfactory results.

Summary

The uniform policy followed with regard to the disposal of sewage in the national parks has been to avoid contaminating streams or interfering in any way with the use of streams for fishing or recreation, and to locate, construct, and operate treatment and disposal plants so that they will not only be free of odors and any other nuisance, but will conform to the high standards of the Park Service in relation to architecture and preservation of the natural scenery in the parks.

Acknowledgments

The writer is indebted to P. A. Sanitary Engineer O. C. Hopkins and Sanitary Engineering Assistant H. R. Carlson for valuable assistance in the preparation of this paper and to Hilliard Hall and Russell White, operators, respectively, of the treatment plants at the Grand Canyon and Yosemite National Parks, for data furnished regarding the operation of these plants.

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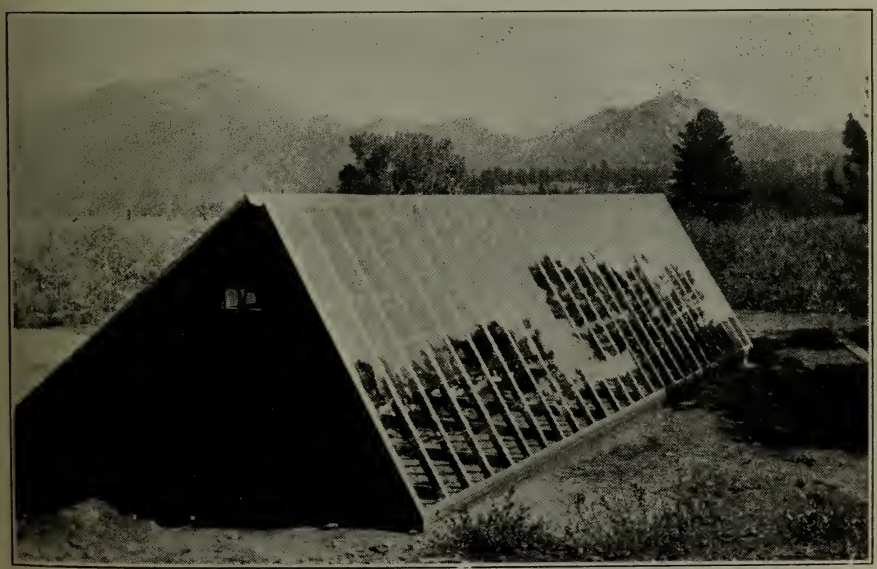


Fig. 4—*Glass-covered Sand Filter, Rocky Mountain National Park.*

DISCUSSION OF PARK SEWAGE DISPOSAL

By ARTHUR P. MILLER*

Mr. Hommon's paper is of particular interest to me because, in 1921, I had the privilege of assisting him when he inaugurated the present system of controlling sanitary conditions in our national recreation areas. Three years of work in the western group of parks gave me a comprehensive picture of the magnitude of this task and of the peculiar difficulties which had to be overcome. In 1923 I was directed to return to the east and, about 1930, due to constantly increasing National Park Service activities in the eastern section of the country, Eastern and Western Divisions were established. Supervision of sanitation in the Eastern Division, which included all areas east of the Mississippi River and, in addition, Hot Springs National Park in Arkansas, was lodged in my office. I continued in charge of this work until 1934.

In 1921, in what is now the Eastern Division, the National Park Service administered only two areas, namely, Acadia National Park in Maine, and Hot Springs National Park in Arkansas. I believe that very few people realize to what extent the number of national recreational, monumental and historical areas under the careful supervision of that service has increased. Contrasted with the two areas in 1921, a summary this year shows the following:

TABLE 1

National Parks	5	
National Historical Parks	1	
National Monuments	9	
National Military Parks	11	
Battlefield Sites	10	
Miscellaneous Memorials	4	
National Cemeteries	11	51
National Parks (proposed) (Mammoth Cave, Shenandoah and Everglades)	3	
National Monuments (proposed)	2	5
National Capitol Parks		1
		57

These areas are not concentrated in any one section, but are well distributed throughout the East.

In the two older areas, Acadia and Hot Springs, sanitation has kept pace with the growth of the parks. Because of the importance of federal activities in the city of Hot Springs, the National Park Service is contributing generously to sewerage extensions and improvements and to new sewage disposal plants. The federal government's investment in those works has justified a controlling interest by the National Park Service in the selection of the designers and in the methods, efficiency and continuity of plant operation. These interests are safeguarded in a formal contract. I understand that a reputable mid-western firm has recently been awarded the work of designing this project.

There was recently completed in Hot Springs a sewage disposal project for the public camp ground which included a system of collecting lines leading to a settling tank, the effluent from which is automatically pumped into sewage trenches on the only available tract of land, a fairly steep hillside adjacent to the main highway. The construction of these sewage trenches, which are merely devices larger than the customary tile lines to permit infiltering and seepage of clarified

* Sanitary Engineer, U. S. Public Health Service, New York, N. Y.

effluent into the ground, was complicated by heavy rock formations. Finally, blueprints had to be cast aside and sufficient patches of soil suitable for percolation sought on the ground. By this method we were able, eventually, to secure what we considered adequate seepage ara. A similar system was designed for the principal public camp in Acadia. There, however, we were fortunate in having a small lake to receive the tank effluent.

One of the newer eastern areas, Colonial National Monument at Yorktown, Virginia, has received considerable attention. This monument has not yet developed to the point where a comprehensive sewerage project is warranted. Therefore, we solved the immediate problems by installing four separate settling tanks with arrangements for discharging clarified effluent into the ground. These installations were at different points in the federal territory, the idea being to provide sufficient facilities to care for the rapidly increasing tourist travel to this historical section. The need for definite and certain soil borings before the construction of any ground disposal scheme was demonstrated last year when we found one of our trenches ineffective. Tight soil, unobserved before design, has partially destroyed the usefulness of this particular installation and it will have to be expanded into a nearby area containing sandy loam of sufficient porosity to satisfy percolation requirements.

During the celebration of the Yorktown Sesquicentennial celebration in 1931, interesting problems were met in the provision of temporary sewage disposal facilities adequate to care for an estimated attendance of 100,000 people in four days. Utilizing large batteries of carefully attended and supervised pit privies, combined with a can system on a public water supply watershed, we successfully satisfied the needs of the situation without complaints.[1]

At the George Washington Birthplace National Monument, small settling tanks with provisions for ground infiltration of the effluent have been built in four places. Here, again, the character of the monument did not justify a single system. Incidentally, before the organization of the Eastern Division, Mr. Hommon had much to do with the original installations in Colonial and George Washington's Birthplace National Monuments.

The other areas in this Division are so new or have been acquired so recently that the provision of sewage disposal facilities has not yet progressed far. However, because of the procurement of funds from the Public Works Administration and on account of the need for usefully employing people without work, much activity is contemplated in many areas and some is going ahead at once.

In both the Great Smoky Mountain National Park (Tennessee and North Carolina) and the Shenandoah National Park Project (Virginia) headquarters development, public camping areas, privately owned but governmentally controlled concessions, will all require systematically planned and substantial works for waste handling. These two large and beautiful areas situated in the midst of heavily populated sections will serve as recreation grounds for great numbers of people. These are not small areas. The final development authorized in the Great Smoky Mountain National Park includes 427,000 acres, which makes it about two-thirds the size of Grand Canyon National Park, approximately four-sevenths as large as Yosemite National Park and somewhat larger than Sequoia National Park. A free and open park of this size in the center of the populous South is bound to attract many visitors.

Mammoth Cave National Park project (Kentucky) and the latest authorized one in the Florida Everglades; the National Historical Park at Morristown, New Jersey; National Monuments like those at Fort Pulaski, Georgia, and Fort Matanzas, Florida; and National Military Parks such as Gettysburg, Shiloh, Vicksburg, Chattanooga and Chicamauka, are all being developed "for the benefit and enjoyment of the people". Keeping pace with the National Park Service, the Public Health Service will continue its co-operative efforts in the sanitary field, insuring the guests of the national government the most adequate and convenient sanitary facilities possible under the circumstances existing at each site.

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SEA OUTFALLS AND OCEAN DISPOSAL OF SEWAGE IN THE EAST AND WEST

By A. K. WARREN*

In any discussion of the subject outlined in the title of this paper it is desirable to have clearly in mind the meaning of ocean disposal of sewage. Sewage, as defined in the American Society of Civil Engineers Definition of Terms, is "A combination of liquid wastes conducted away from residences, business buildings and institutions and from industrial establishments, with such ground, surface and storm water as may be admitted or find its way, into the sewer". A definition of "Ocean Disposal" of sewage is lacking, but by common usage the term seems to have become an all-comprehensive one, embracing the discharge into tidal waters of everything from raw untreated sewage to the highly refined effluent of a complete treatment plant. Obviously such a conception of the term is in error because the retention of any constituent part of the raw sewage at a treatment works takes this type of disposal out of the scope of "ocean disposal of sewage" and should be considered as the disposal of a sewage treatment works effluent, regardless of the extent of such treatment. Furthermore, the existence of an outfall sewer extending into the ocean should not be taken to signify that ocean disposal of sewage is being practised, for in a number of places the sewage is treated by one method or another and the outfall is conveying a treated effluent for disposal into the sea. It would appear that ocean disposal of sewage should be defined as the emptying or disposal of sewage from any sewerage system directly and without treatment into tidal waters. A full realization of this is necessary in order that one may properly visualize the status of ocean disposal of sewage along the sea coasts of the United States.

The disposal of sewage into tidal waters is the oldest sewage disposal practice; as is perfectly natural, however, tidal waters may be overworked by the concentration of large amounts of sewage wastes in a relatively small area and develop a condition which, according to our standard of living, is a nuisance to the sense of vision or of smell, or an actual menace to health.

In small coastal communities, where controlling factors are ideal, ocean disposal of sewage is at once the most economical and probably the most sanitary method to be adopted, but it must be admitted that in and around the coastal centers of great population factors are not ideal, due to overloading of tidal waters with pollution, and true ocean disposal is rapidly being eliminated.

Nearly every center of large population on the sea coast is situated on a bay or other indenture from the normal coast line and the dis-

* Chief Engineer and General Manager, Los Angeles County Sanitation Districts, Los Angeles, California.

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posal of sewage from such areas is not usually directly into the sea, but into the bay, river mouth or, in some cases, artificial harbor, where the purification potential of the tidal waters is greatly reduced through lack of salt water circulation. San Francisco Bay may be mentioned as a case in point where the wastes, both domestic and industrial, from a large population are discharged into tidal waters without treatment at numerous outlets along the bay shore. Conditions there are quite unsatisfactory, and at many points floating sewage solids are stranded along the beach to develop objectionable odors or an actual menace to public health.

Puget Sound, in the vicinity of Tacoma, is equally objectionable, and similar conditions exist at other points along that shore line. The same holds true to some extent around Portland. At no other location of importance on the west coast of the United States is ocean disposal practiced. This may be said particularly of the coast line of California, for at Los Angeles, San Diego, Santa Barbara and at many smaller communities, sewage is treated in some degree, prior to discharge.

Along the east coast, Boston Harbor is an outstanding example of ocean disposal of sewage, where raw sewage is discharged into the bay. This differs materially from the New York area, where large amounts of wastes are discharged at points more or less remote from the sea. In the Boston area, the discharge of sewage at the sea bottom in deep water through relatively long outfall structures, has minimized objectionable conditions, as has been indicated by careful study of the harbor water, but the Moon Island outlet continues to discharge relatively close to shore and though somewhat isolated is, nevertheless, not free of criticism.

In the New York Harbor area, much of the sewage is pre-treated in some manner before discharge into the rivers and harbor and much of the pollution load is eliminated. With the completion of the Ward's Island activated sludge plant the pollution factor will be further reduced. Both the Passaic Valley sewerage works and the recently completed Essex and Union County system discharge an effluent after plant treatment by subsidence. Notwithstanding, the harbor is far from clean and an impressive amount of money will be needed for treatment facilities before the harbor water can be restored to the purity that existed prior to the beginning of the last century. New Bedford, Massachusetts, advantageously situated, resorts to ocean disposal quite successfully.

Baltimore provides biological treatment through sprinkling filters. The discharge from this plant is a number of miles removed from the sea, with little diluting water, and such treatment is essential to maintain conditions and to protect oyster beds in that vicinity. Paterson and Trenton, New Jersey, and Providence, Rhode Island, treat the sewage by subsidence prior to disposal. In the case of New Jersey, it has been found that the discharge of a sewage effluent after treatment by subsidence and chlorination through outlets extended into

the sea, has quite satisfactorily corrected a former condition of pollution along the many bathing beaches.

From the standpoint of economy of first cost and of operation, nothing can approach disposal by dilution as a means for getting rid of municipal sewage. It is a simple and direct method of employing the forces of nature to do an otherwise difficult and complex job. It remains the **best** method, provided satisfactory conditions are maintained in the ocean outlet surroundings. Certain obvious safeguards must be erected.

(a) There should be no offensive floating matter visible over the outlet or stranded upon neighboring shores.
(b) No offensive sludge beds shall form.
(c) Decomposition of the organic content shall take place on an aerobic basis.
(d) A sufficient oxygen balance shall always be maintained in the immediate diluting water, both at the surface and over any deposits, to maintain fish life.
(e) The concentration of toxic trade wastes shall not be such as to destroy the necessary oxidizing bacteria.
(f) Pollution in objectionable concentrations shall not be such as to reach shell fish beds.

There are others, but of less importance, and nearly all depend upon the foregoing. Standards for bathing waters shall, of course, not be violated.

When natural forces become inadequate to cope with the task that is placed upon them through the discharge of undue pollution loads it becomes necessary to aid nature by resorting to some treatment of sewage before discharge.

Fortunately, much more is known today about the behavior of sewage in sea water than was the case prior to the beginning of the last century. With the newer knowledge, one is equipped to predict with a fair degree of certainty what may take place in the tidal waters about an outfall. This knowledge may be summarized in a few fundamentals which are based upon practical experience with existing sea outfalls; research regarding the behavior of fresh water in salt water and the longevity of disease germs in sea waters.

The most accurate measure of the ability of tidal water to purify sewage discharged therein is its dissolved oxygen content. Winds, currents, proximity to beaches used for recreational purposes or upon which sewage may be deposited have an important bearing upon whether or not the sewage may be brought into contact with dissolved oxygen sufficiently far from shore to maintain a buffer strip of clean water between the point of discharge and locations where pollution cannot be tolerated. Research and experience indicates that the better the initial dispersion of sewage into sea water the less will be the tendency towards stratification, evidenced by a large area of floating sewage over or away from the outlet. The longevity of disease germs in sea water is not well understood, but results of bacteriological surveys, made in the environs of sea outfalls, are rather conclusive in showing that waters complying with bathing standards

may be maintained close to sea outlets if other favorable conditions prevail.

The pollution potential of a sewage is more readily, and may be more accurately, determined. Laboratory methods permit one to measure with certainty the oxygen requirements of any sewage or treatment plant effluent. Experience has taught that an essential to the proper operation of a sea outfall is the removal from sewage of coarse suspended solids prior to discharge. This may constitute treatment of the nature of fine screening or plain subsidence and skimming. If it can be accompanied by grease removal conditions are greatly improved. Such treatment is inexpensive and the small investment per million gallons flow as a rule yields large dividends in cleanliness.

Obviously, coarse bar screening does little to improve the sewage condition—merely removing coarse suspended and relatively inert materials. Fine screening to the contrary contributes materially to absence from pollution—not by the removal of a large percentage of putrescible matter, but rather by extracting large solids, floating and otherwise, which tend to drift long distances before oxidation takes place, or to form sludge beds on the ocean bottom. Treatment by subsidence accompanied by grease removal permits only the very fine suspended particles to pass off with the effluent, while the grease, by which so many sewage fields are identified, is retained in a large measure at the plant. It seems unlikely that sludge banks will accumulate under reasonably favorable conditions if all of the sewage solids which will settle at the very slow velocities employed in sedimentation tanks have been removed. Further, it is almost axiomatic that the finer the solids in the effluent the more readily will they be oxidized.

Chemical precipitation, subsidence followed by filter beds and the activated sludge process go further to improve conditions in the order named, and it may be stated that in the latter process the ocean merely acts as a receptacle for slightly polluted water for which there is no other need as yet in many areas. To state that disposal of the effluent from the proposed Ward's Island plant in New York Harbor is ocean disposal is ridiculous—disposal by separation takes place at the plant, with 95% or more of all pollutional material retained therein.

After observation and investigation, it may be said that ocean disposal of sewage from metropolitan areas on the east and west coast will soon be a thing of the past, and that little, if any, sewage will be disposed of in the sea without some prior treatment ranging from fine screening to the more refined processes. There are few locations where it can be carried on much longer with success. The necessity for separating out the less readily oxidizable substances at a sewage treatment plant and giving the tidal waters a more certain chance to do the remainder of the job without nuisance or menace to health is well recognized today. More and more thought is being

given in the more populous seaports to more adequate yet economical methods of disposal.

The late George W. Fuller, whose experience during the years of sewage development were almost without parallel, concludes in his most recent volume, "The natural laws governing the disposal of sewage by dilution are generally applicable to disposal in lakes, oceans and tidal estuaries"; further, that "Disposal of sewage in large bodies of fresh, salt and brackish water is also widely practiced. As with rivers, this procedure has its limitations. When carried out reasonably and intelligently, however, it is a suitable and proper method." He further says, "The problem is how to regulate such uses of large bodies of water without injury to public health or creation of objectionable nuisances. Obviously the solution lies in advantageous adjustment to local conditions, after careful investigation, and in supplementing the dilution process by treatment works as they become necessary or desirable to avoid overbalancing the capacity of the receiving water."

To this view the speaker subscribes, and adds the thoughts that there appear to be few important seaboard cities where supplemental works are unnecessary, and that true ocean disposal will not long be tolerated but will of necessity be supplanted with plant treatment and dilution of a treated effluent.

DISCUSSION OF OCEAN SEWAGE DISPOSAL

By SAMUEL A. GREELEY*

I have not had an opportunity of studying Mr. Warren's paper, but have prepared some preliminary comments. Sewage or sewage effluents from coastal cities generally reach the ocean in a relatively short time. The methods of discharging said sewage or effluent into the ocean are different in various cities and depend on local conditions more than is often considered.

The characteristics of the local waterways and the point of discharge are important as regards use, depth, currents, winds, reefs, tides and the like.

The characteristics of the sewage are important, including the content of oily matters, the number of B.coli and other bacteria, the amount of industrial sewage, the mineral constituents, and the age of the sewage.

Ocean disposal of sewage should be planned with due regard to the following considerations:

a. Visual pollution.
b. Air pollution.
c. Water pollution, especially near shore.
d. Depletion of the dissolved oxygen.

Related to these items is the permanence of the construction so as to provide discharge at place selected.

There are a number of ocean outfalls in operation, a few with pre-treatment of the sewage by plain sedimentation, and generally with varying depths of water and current conditions. Some data as to the mixing of the sewage and the sea water at the outlet is available for three outlets in Massachusetts, as follows:

* Greeley and Hansen, Chicago, Illinois.

Project	Depth in feet	Parts of sea water to one part of sewage as determined from chemical analyses of the mixture as it comes to the surface over the outlet
Nut Island	27	6.6
New Bedford	30	16.3
Swampscott	50	50

NOTE: See Massachusetts Senate Document 450, 1916, p. 34.

Under certain conditions, the discharge of sewage through multiple outlets is helpful, as shown by the results in New York Harbor with the Passaic Valley project and at the Deer Island outlet in Boston Harbor. I have been over the Passaic Valley outlets when the discharge of sewage effluent could not be observed.

Low head pumping to provide flexibility in the rate of discharge sometimes is part of an economical project.

Not a great deal is of record as to the death rates of bacteria in sea water, especially B.coli. The following table gives some data collected by the Massachusetts State Department of Health a number of years ago:

BACTERIA IN SEA WATER AT VARIOUS DISTANCES FROM SEWER OUTLETS

Location	Hours after discharge	Feet from outlet	Bacteria per cc.	
Boston—Nut Island			610,000	Screen House Sew.
	0	0	230,650	
	0.50	200	26,080	
	1.00	260	525	
	1.50	1400	46,220	
	2.02	2500	850	
	2.87	3500	180	
New Bedford	0	0	219,850	
	0.32	800	2,650	
	0.82	1800	27	
	1.32	2600	17	
	1.82	3150	63	
	2.32	4900	95	
Swampscott	0	0	99,750	
	0.18	150	38,800	
	0.68	300	21,500	
	1.18	1300	2,400	
	1.68	1600	13	
	2.18	2100	66	

Reference: Annual Report, Massachusetts State Department of Health, 1915, pp. 349, 353 & 354.

It is important, in my opinion, to plan for the discharge of sewage into ocean waters with due regard to adequate pre-treatment so as to properly control the effect of the discharge on the adjacent waterways.

THE TREATMENT OF "BEER SLOP" AND SIMILAR WASTES

By A. M. BUSWELL*

The wastes from breweries and distilleries are typical of a rather large group of industrial wastes for which a common method of treatment is in general applicable. In this group we would include wastes from breweries, distilleries, grain vinegar, cereal beverages (ovaltine), starch manufacture, creameries, meat packing, citrus fruit juice, pea, bean and corn canneries, and beet sugar; in short, most of the industries which produce food and drink in a "ready to use" condition.

Nearly all of these industries use water for three purposes: (a) process water, which is relatively small in amount but when discharged carries several per cent of organic matter; (b) wash water used to clean equipment, floors, etc., which is variable in quantity and may be roughly of the concentration of domestic sewage; and (c) cooling or condenser water, which is usually several times the volume of (a) and (b), but with proper piping it may be discharged in an uncontaminated condition.

This paper deals primarily with the treatment of "process water" or more properly "process by-product" in the case of certain industries such as creameries and citrus fruit juice bottlers. In the treatment proposed it is assumed that this concentrated waste (a) can be separated completely from (c) and more or less completely from the more dilute liquids composing the wash water (b).

The concentration (1, 3, 6, 7, 8) of these process liquors as shown in the tables below range from 1% to 6 or 7% total solids, of which the major portion is organic matter in true solution. The inorganic matter (ash) and settleable solids run considerably under 50% of the total, and the oxygen consuming substances are almost entirely in solution.

With material of this sort the usual expedient of sedimentation produces relatively little improvement. The addition of chemical coagulants is likewise of little benefit as far as b.o.d. is concerned. The reason for this failure is apparent when we stop to consider that much of the organic matter in these wastes is in a state of true solution (i. e., like a salt solution or a sugar solution) and cannot be removed by coagulation. In this respect they differ from domestic sewage, for it has recently been shown that passage through an "ultra filter" (i. e., a filter which will remove true colloids) will reduce the b.o.d. of (9) ordinary sewage to zero. Substances in true solution are not removed by "ultra filtration".

The aerobic methods of treatment, trickling filters or activated sludge, may be employed to remove dissolved organic matter, but the loading limits for good results are very low (6). Rates of 10,000 to

* Professor of Chemistry, University of Illinois, Chief of State Water Survey.

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50,000 gallons per acre per day are required for the undiluted wastes on trickling filters and aeration periods of 24 hours or more with high air consumption are required when the activated sludge process is used. The sludge produced tends to be light and feathery and settles poorly.

One of the most embarrassing characteristics of high organic wastes is the rapidity with which they become sour. Acetic, lactic and other organic acids develop in a few hours to give acidities of several thousand parts per million. In some cases these acids develop during the normal manufacturing process and the wastes as discharged are strongly acidic. Experience has shown that sour wastes cannot be treated by aerobic methods even at the low loading given above. Neutralization must be employed and frequently dilution is necessary, water or domestic sewage being used if available. The necessary dilution ratios run from 1 to 10 to 1 to 100. Where the industry operates only a few months a year broad irrigation or lagooning at the rate of 10,000 gallons per acre per day may be employed.

It is apparent, then, that ordinary sewage treatment methods applied to industrial wastes of this character require an outlay for plant and equipment which is a heavy burden on the industry. Some manufacturing plants to handle their wastes in this way would have to build treatment works capable of purifying the wastes from several million people.

Since the concentrations encountered are similar to those found in the sludge from sedimentation tanks it was early suggested that these wastes might be handled as sludge is handled, namely, by anaerobic or septic digestion. Attempts to accomplish this were unsuccessful due in most cases to the extensive and rapid production of acids which arrested all further bacterial decomposition. It was noted that if the wastes were diluted with sewage (1:10) (3) the acidity could be controlled and complete anaerobic decomposition of the organic matter brought about. Dilution, however, has the disadvantage that the total volume to be treated is increased, necessitating extra tankage.

In the case of wastes containing more or less fibrous material or grease a firm scum or mat forms (5, 8) at the top of the digesting tank, frequently to considerable depths, and further hinders the process by creating an acid zone and decreasing the effective volume of the tank.

These limitations to the anaerobic method of stabilization have been under investigation in the laboratories of the Illinois State Water Survey for about ten years. The solutions proposed are as follows:

Control of acid production. It has been shown by numerous investigations (2) that practically any kind of organic matter except mineral oils will decompose under the action of anaerobic bacteria to form methane and carbon dioxide. Fats, proteins, carbohydrates, alcohols, and even phenols are decomposable in this manner. The chemical reactions which take place in this decomposition occur in the

main in two steps; the complex organic molecules combine with water to form the simpler organic acids (acetic, propionic, etc.) and then these acids decompose to methane and carbon dioxide. If an abundance of food material is available for the bacteria they tend to form acids more rapidly than the acids can be decomposed. It is well known that under these conditions the acid soon reaches a concentration at which all bacterial action is stopped. If, on the other hand, the amount of food material is properly limited, the bacteria will decompose the acids as fast as they are formed, and the fermentation goes on smoothly and continuously. Fresh material may then be added regularly to the fermentation vessel in controlled amounts.

The Duclaux* method for total volatile acid is used to determine the rate of accumulation of acids during digestion. These organic acids are only slightly ionized and it is the acid radical not the hydrogen ion which must be transformed into CO_2 and CH_4. For these reasons it has not been found possible to depend on the pH determination for control of the process.

The limit of acidity for smooth continuous fermentation has been found for most materials to be about 2000 p.p.m. calculated as acetic. When the acidity of the liquor in a fermentation tank exceeds this value it may be reduced either by decreasing the rate of feed of raw material or by dilution. Decreasing the rate of feed would involve storing or by-passing untreated waste which would be objectionable. Dilution with water may be used, but we have found it advantageous to carry out the fermentation in two or more tanks operating in series using the spent liquor for dilution. The rate of feed is adjusted so that the acidity in the first tank is kept near the upper limit in order to obtain maximum efficiency. The secondary tanks receive the overflow liquor from the first tank at a rate to keep the acidity at a low value. To reduce the acidity the liquor from the secondary tanks may be pumped to the first tank, allowing a like amount of liquor from the first tank to flow into the second tank. In other words, the liquor in the two tanks is intermixed and the acidity reduced. Suppose in an installation with two tanks of equal size the acidity in the first tank has increased to 2500 p.p.m., while that in the second is 500 p.p.m. After back circulation of liquor from the second tank for a few minutes, allowing that displaced from the first tank to flow to the second, the acidity will be 1500 p.p.m. in both tanks. This is below the tolerance limit and the feed of raw material to the first tank may proceed without interruption.

Scum and foam control. Wastes of a greasy or gummy character frequently produce a scum over the top of the fermentation tank. If allowed to accumulate this scum becomes sour and impairs the general operation of the tank. In our experience it can be easily controlled by pumping liquor from well above the sludge line and allowing it to flow back onto the scum. A few minutes a day of this sort of circulation is sufficient to prevent any appreciable accumulation of

* State Water Survey Bull. 30, p. 77, or standard texts on Organic Analysis.

floating solids. Some operators have suggested circulating sludge from the bottom of the tank over the scum. This is no doubt effective but it impairs the quality of the digested sludge.

Foam may be controlled in a similar manner, but in this case the discharge at the top of the tank should be at a low velocity to avoid any jetting action. A high-speed jet of water frequently produces foam.

Fibrous wastes. Packinghouse wastes (8), citrus fruit pulp, and sewage screenings (5) tend to form a fibrous mat over the top of the fermentation tank which cannot be controlled by circulation as described above. A special mechanical digester (8) has been designed to solve this difficulty.

This digester consists of a perforated horizontal drum submerged in a covered tank. A feeding tube pierces the outer wall of the tank at a point within the circumference of the drum. The fibrous wastes are fed automatically or manually through the feeding tube into the perforated drum inclosed in the rectangular tank. Both ends of the drum are equipped with seal rings. These allow the drum to be turned in its bearings without the escape of fibrous material from the drum out into the rest of the tank. The digester is filled with water or sewage until it runs out the overflow pipe. A gas-tight cover and water-sealed hood serve to keep out air and collect the gases formed during the digestion. Slow or intermittent revolution of the drum liberates the entrapped gas bubbles and breaks up the thick mat which collects at the top. Frequent charging of the tank with fresh waste, together with revolution or inversion of the drum, causes the digested material to work itself out through the opening in the lower end of a baffle into the residue compartment. This digested material is still fermenting sufficiently to cause the entrapping of gas bubbles within its mass, which, in turn, causes it to float to the top of the residue compartment from which it can be removed periodically with forks or other suitable means.

For the treatment of beer-slop from distilleries and steep water from breweries the acid control is the most important operating factor. By taking advantage of this method of control it has been possible not only to treat these sour wastes but to handle them at loadings of 0.3 to 0.9 lb. of organic matter per cubic foot of tank volume per day. These figures are to be compared with loadings of 0.05 to 0.08 lb. per cubic foot for domestic sewage sludge. Table I summarizes data on a wide variety of wastes.

The gas production per unit of tank volume is, of course, increased proportionately by these heavy loadings. Three cubic feet of gas per cubic foot of tank volume are easily obtained and twice that rate is attainable. Since the principal cost of anaerobic fermentation is the installation charge, it then decreases proportionately with increasing loading rate. Gas production under these conditions is taken out of the waste disposal class and becomes a profitable manufacturing process. Calculations based on the data in Table I indicate that a gas

of 540 b.t.u. can be produced for a cost as low as three cents per thousand cubic foot, although ten cents would be the cost in many cases. As the waste to be treated becomes more dilute, the costs naturally increase. The character of the wastes is also a factor, the fibrous wastes decomposing more slowly than the soluble by-products.

Table III summarizes three batch experiments with citrus pulp. In our experience batch fermentation requires about ten to twenty times as long a period for a given degree of gasification as is needed when the material is fed continuously in controlled amounts. It should be possible to treat citrus pulp on a large scale at about the rate that proved satisfactory with paunch manure.

Effluent quality. The degree of purification accomplished varies from 75 to 90%. Since these raw materials frequently have b.o.d. values ranging from 15,000 to 35,000 p.p.m., the effluent b.o.d. may run from 1000 to 3000 p.p.m. Aerobic methods may be applied to the effluent where necessary. Naylor, more than thirty years ago, showed that even a short septic action treatment of such wastes previous to trickling filters was highly advantageous. The volume of these wastes is so small in proportion to the clean water discharge that the dilution available from this source may be sufficient in some cases. Distilleries discharge about six times as much cooling water as beer-slop.

In some cases with which we are familiar the domestic sewage flow is ten to twenty times the volume of heavy industrial wastes. With preliminary anaerobic treatment the effluent could be discharged into the sewers without producing an abnormal industrial load.

Comparison of costs. Insofar as the anaerobic method is applicable it is decidedly the simplest and cheapest method of converting organic matter into inoffensive materials. Even in the conventional type of sewage treatment plant it is in the sludge digestion tank that 60 to 70% of the organic matter is finally stabilized, the end products being insoluble combustible gas and humus.

A comparison of costs per pound of matter stabilized was worked out by the writer and Dr. C. S. Boruff for creamery wastes (6). The figures are worthy of serious consideration.

On the basis of an average feeding of one-twenty-fifth of a volume of milk waste (undiluted basis) per day per tank volume, it would require a tank, or tanks if operated as a two-stage process, of 5.72 cubic feet capacity for the anaerobic fermentation of one pound dry weight of milk waste solids. At 50 cents per cubic foot, this amounts to only $2.86 per pound of milk solids treated per day. This fermentation would remove at least 95% of the pollution load. The remaining 5% contained in the overflow liquor could be stabilized readily on filters. Assuming that this final treatment could be made at a cost similar to that given for filter treatment by various investigators, the total investment for complete treatment would be $8.70 per pound of solids if trickling filters were used following the anaerobic digestion, or $17.46 per pound if sand filters were used, as compared with $116.80

TABLE I—FEEDING AND GAS PRODUCTION RATES
Obtained During Thermophilic Digestion of Various Industrial Wastes

Type of Waste	Rate of Feed		Gas Recovery	
	Volume Basis	Solids Basis	Volume Basis	Solids Basis
	Vol./day / tank vol.	T.S./day / cu. ft.	Vol./day / tank vol.	Cu. ft. / lb. T.S.
Commercial Solvents' Beer-Slop (Acetonic)				
While fermenting rye	1/2	0.93	7.0	7.5
3.3% total solids, 91% volatile	1/4	0.62	4.2	8.6
	1/6	0.31	3.0	9.7
While fermenting corn				
2.0% total solids, 92% volatile	1/4	0.33	3.7	11.0
Heinz Distillery Waste (pH = 4.1)				
7.1% total solids, 96% volatile	1/28	0.16	2.0	12.5
Buttermilk and Whey Waste (pH = 5.0)				
7.0% total solids, 91% volatile	1/29	0.15	1.6	10.7
Artichoke Waste		0.095	0.81	8.35
Extracted Chickory		0.156	1.64	10.5
Sugar Beet Waste		0.078	0.96	12.3
Packing-house Paunch Manure		0.37	3.1	8.95

TABLE II—PARTIAL ANALYSIS OF CITRUS PULP

	Per cent
Moisture	85.5
Ash	0.46
Ether extract	0.38
Crude fiber	0.84
Protein	1.28
Carbohydrates	9.38
Organic nitrogen	0.197
Kjeldahl nitrogen	0.198
Total nitrogen (salicylic)	0.208

(All of above data are on a wet basis) pH = 4.0

TABLE III—ANAEROBIC DIGESTION OF CITRUS PULP

Bottle number	1	2	3
Time, days	180	180	180
Weight of pulp added			
(a) Wet (gms.)	69	138	273
(b) Dry (gms.)	10	20	40
Volume of gas evolved (cc.) N.T.P.	7,045	12,955	7,105
Volatile acids as acetic at end (p.p.m.)	90	90	4,880
pH at end	6.0	6.0	5.0
Per cent digested	84.0	78.0	

per pound if trickling filters were used alone, or $292 per pound if said filters were used. The above figures are not given to show actual costs, but rather relative costs of the two processes.

Recovery of stock food. It is not within the scope of this paper to discuss the evaporation of wastes for stock food recovery. It is doubtful whether this can be done with profit unless the solids run higher than 7%. We are certain that with 1 to 3% solids the net profit is in favor of anaerobic fermentation.

As a waste disposal process evaporation is not a complete solution to the problem since the "carry-over" from the evaporators amounts to 400 to 1000 p.p.m.

The data on which this paper is based were taken from publications prepared with the writer's former collaborator, Dr. C. S. Boruff.

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DISPOSAL OF WASTES FROM WINERIES

By FRANK E. DE MARTINI*

The repeal of prohibition has revived the wine industry in this country. California, always a leader in the industry, is again an extensive wine-maker. According to estimates and statistics from scattered sources, there were approximately 500 wineries in the state in 1933, crushing some 440,000 tons of grapes and producing 40,000,000 gallons of dry wines, 20,000,000 gallons of fortified wines and 2,441,000 proof gallons of brandy. A "proof gallon" contains 50% alcohol, which in the industry is referred to as 100 proof.

Briefly, the procedure in making wine is as follows: The grapes as received from the vineyard are first crushed, and the stems removed and discarded. The grape skins, seeds and juice are then put in tanks where fermentation occurs for varying periods, generally six to nine days. The production per ton of grapes is roughly 150 to 180 gallons of new wine. This new wine, which is rather turbid due to the fermentation, is then decanted or pumped to other tanks and the heavier sediments and seeds, together with the floating skins and particles of stems, are removed as a garbage-like material called "pomace".

In the succeeding weeks or months the wine itself is moved successively from tank to tank, during which time additional sediment or "lees" consisting of yeast, cream of tartar, and other organic matter settles to the bottom, and in the course of decantation, is thus separated from the wine. In this "racking" process, in which the wine is moved from tank to tank, and also in the final stage, the wine may be and usually is passed through press filters to give greater clarity. To this point the process usually yields a "dry" wine; that is, one in which all or most of the sugar has undergone the fermentation process. The alcohol content of dry wine is considered as low; that is, from 9 to 14%.

"Sweet" wines contain unfermented sugar, and to preserve them a higher alcohol content is needed, varying from 18 to 22%. To obtain the brandy or alcohol for this "fortification" some of the grape juice after fermentation is put through distillation towers heated by live steam or steam coils and the alcohol is condensed by cold water coils. The waste or residue therefore is the wine minus its alcohol. The wine or material that is used as a source of alcohol is of a miscellaneous nature, including inferior wine that has turned sour, extracts of lees and refermented pomace, fermented fruit juices, etc. Thus the still slops are variable in strength and solids, obnoxious in character, and are always the worst waste from a winery. The population equivalent of the undiluted slops appears to be about 225 persons per ton of grapes, whereas the lees on the same basis have a population equivalent of about 35 persons.

* Junior Sanitary Engineer, Bureau of Sanitary Engineering, California State Department of Public Health.

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In order to make the distillation efficient, the input to the still is reduced by dilution with water to an alcohol percentage varying from 7 to 9%. Furthermore, comparatively large quantities of water are used in the cooling process, thus making the quantity of wastes from a still the largest single source of waste water in a winery

In California, sweet wines are made close to the vineyards in the hot valleys, in Fresno, San Joaquin, and Sacramento counties, and in San Bernardino County in the south; and from the counties of Napa and Sonoma come the dry wines. Santa Clara County makes both sweet and dry wines in about equal proportion.

In every winery, whether making sweet or dry wines, one finds as waste, the garbage-like residue consisting of stems, leaves, skins and seeds, which the industry terms pomace, and which amount to a little less than half the volume of the grapes received; also, the sediment-like organic sludge called "lees", which amounts to three or four per cent of the wine produced, or roughly five to seven gallons per ton of grapes; and finally, the various weak wash waters from the cleaning of tanks, utensils, filters and from washing down floors if they happen to be of concrete. There is also some uncontaminated water as from heating and cooling coils, particularly in the hot climates where fermentation tanks are cooled by circulating water to avoid killing the yeast in them. In addition to these wastes, wineries in which sweet wines are made and brandy distilled have the still slops previously mentioned, and the water used for condensing the brandy. Such wineries also produce a slightly increased amount of lees.

There are many variations in the operations of a winery, depending upon the type of wine made. For example, some wines require heating, in which case steam or hot water coils are used, producing additional, though generally not large, amounts of uncontaminated water.

Disposal of Wastes

The solid wastes from a winery are essentially pomace which is the residue consisting of grape skins, seeds and particles of small stems. This material contains a little moisture and is generally piled near the plant and is later hauled away by farmers for use in vineyards as fertilizer. Local odors of a vinegar-like nature are the chief source of nuisance. Chloride of lime helps to keep down the smells. At one large winery the pomace is treated with hot water and distilled to produce "grappa", a special type of brandy. In this case the residue from the still is a spent pomace mash which is flushed out onto the land, where the water drains out of it and the solids are later plowed into the soil. In some wineries the pomace wash water may be used to dilute the wine to be distilled. In either process the pomace is less subject to souring and at the same time some alcohol is recovered.

Lees are a thick residue resembling mine slimes which settle out as the wine clarifies. The volume is three to four per cent of that of

the wine produced. It is highly organic, tests indicating that for one ton of grapes the population equivalent might amount to about 35 persons. In some cases the lees are diluted and mixed with the wine material passed through the still. In this case it contributes to the volume and strength of the still slops. In other cases it may be dried on wood trays, resulting in a light pumice-like material which is used in making cream of tartar. In either case the spent lees are simply sluiced out as a sludge for ultimate disposal. In the newer freezing processes for quick aging of the wine the lees come down in a dense cake which is easily hauled away.

The liquid wastes are properly divided into the strong still slops, the medium strength wastes from the washing of floors and tanks, and the uncontaminated cooling and condenser water. At the present time the wineries make no effort to keep these various wastes separate for ease of disposal, but it is evident that the task of disposal, especially on land, would be greatly simplified were the wastes kept segregated.

As a rule the wineries are located in vineyards of large acreage in which the soil is naturally light and porous, with good underdrainage. But these characteristics of soil are not universal and in some cases the top soil, though light and porous, is thin and underlaid by a dense hardpan. It is in these regions that the troubles with winery wastes are particularly acute. Unfortunately these particular wineries happen to be adjacent to and on the windward side of neighboring towns.

The utilization of land for the disposal of the liquid wastes is also crude. Dry wine wineries, by reason of the small volume of wastes, often use nothing more than open leaching basins. In some cases there may be a series of these basins in which the upper units yield some clarification and the lower units are the more useful for leaching. In still other wineries one will find wastes run out in furrows between the vines, but when still slops are disposed of in this way there is danger that the wastes will kill the vines. In other cases the wastes are simply disposed of as by broad irrigation, with more or less rotation of flow from one area to another. Though crude, it does not follow that the methods are conducive to a nuisance in every case. It is a matter of environment and prevailing winds.

The acreage of land required is usually surprisingly small, but likewise the variations between wineries is marked. Thus two wineries in the Fresno district, which made a million gallons of sweet wine each, succeeded in disposing of their liquid wastes on 2 to 3 acres of land, without ponding or nuisance. In this case the soil was sandy, or fine gravelly, and very absorptive. Another winery made only 400,000 gallons of sweet wine but had difficulty in disposing of wastes on two acres of land; while another making 650,000 gallons of sweet wine required four acres and much attention to alternating the flow from check to check.

At the beginning of the 1933 season there were only four wineries out of some 500 that disposed of their wastes to streams, and two

more desired to utilize this method. In one of the rivers studied in which the dilution was great, 1 part of waste in about 1300 of river water, it was evident that these highly carbonaceous wastes left their mark on the river, as a Sphaerotilus-like fungus growth along the water's edge below the outlets, and, in fact, for many miles down-stream. These fungus growths occurred notwithstanding that other effects were so slight as to be scarcely measurable. By reason of a strong effort in California to preserve streams from pollution, their use by the wineries has been objected to. One of the wineries has ceased to sewer to the river, while the other two have been denied permission to build sewers for the purpose.

The following tabulation, Table I, indicates roughly the quantities and relative strengths of wastes produced at wineries making dry and sweet wines. The figures as presented are based on very limited tests and observations and should be accepted with reservations, to give some idea of relative values.

TABLE I

APPROXIMATE QUANTITIES AND AVERAGE STRENGTH OF WASTES FROM WINERIES

(Expressed as for one ton of crushed grapes)

Type of Waste	Dry Wine		Sweet Wine	
	Quantity Produced	Strength (Pop. Equiv.)	Quantity Produced	Strength (Pop. Equiv.)
Pomace	600 lb.		600 lb	
Lees	3% to 4% of wine or 5 to 7 gal./ton.	35	3% to 4% of wine or 5 to 7 gal./ton.	35
Still Slops	None.		80 gal. for .4 ton grapes (.4 ton out of each ton needed for brandy to fortify balance.)	90
Med. Strength Liquid Waste: Wash water from floor, tank, filters	100 gal.	5	100 gal.	5
Uncontaminated: Condenser water—still	None.		300 gal.	
Condenser water—tanks	15 gal.	0	15 gal.	0
Totals	120 gal. per ton	40 pop. equiv.	500 gal. per ton	130 pop. equiv.

In wineries having dirt floors, wash water may be reduced as much as 50 gallons per ton. If cooling towers and recirculation systems are used, condenser water from stills may run much less than above.

Nothing has been done in California in the way of biological or chemical methods to condition winery wastes. In fact, even the use of settling tanks is practically unknown unless one includes the settling basins. It is a question, however, whether settling tanks would be of value in treating these wastes which ferment so readily. The principal outlook for improvement in the methods now used is expected to be in the better application of the principles of disposing of such wastes on land, patterned after the methods that have been so essential in the operation of sewer farms.

Table II gives certain information for a typical winery making sweet wine in the Lodi district of San Joaquin County.

TABLE II

WASTES PRODUCED, AND ANALYSES OF WASTES OF A TYPICAL SWEET WINERY IN SAN JOAQUIN COUNTY

Based on 4-day measurements and tests, 8:00 a.m. to 6:00 p.m.

Average tons crushed daily (seasonal)	100 tons
Two stills in operation	Input 1000 gal. per hr. each
Still slops	900 gal. per hr. each
Cooling water	2000 gal. per hr. each
Rinsing water from floors, tanks, filters, etc.	Av. 1800 gal. per hr.
Av. flow of total wastes	7600 gal. per hr.
Max. flow of total wastes	9700 gal. per hr.
Lees	460 gal. in four days

MIXED LIQUID ANALYSES OF WASTES

	4 days' composites Average for
5 day B.O.D.	4800 p.p.m.
Oxygen consumed	9200 p.p.m.
Total solids	10400 p.p.m.
Acidity	1140 p.p.m.

Table III gives similar statistics for a typical dry wine winery in the same district.

TABLE III

WASTES PRODUCED, AND ANALYSES OF WASTES OF A TYPICAL DRY WINERY IN SAN JOAQUIN COUNTY

Based on 3-day measurements and tests, 8:00 a.m. to 6:00 p.m.

Average tons crushed daily (seasonal)	60 tons
Average hourly flow (total plant wastes)	307 gal. per hr.

ANALYSES OF MIXED LIQUID WASTES

	Av. of 2 days	One day when lees from two 25,000-gal. tanks were being dumped
5-day B.O.D.	525 p.p.m.	10,500 p.p.m.
Oxygen consumed	460 p.p.m.	13,800 p.p.m.
Total Solids	825 p.p.m.	18,400 p.p.m.
Acidity	113 p.p.m.	2,200 p.p.m.

REMARKS BY W. A. CHOWEN* ON "WORKMEN'S COMPENSATION INSURANCE RATES"

Gentlemen of the Seventh Annual Convention:

In order to clarify my position, may I begin by explaining that the California Inspection Rating Bureau, which I have the honor to represent, is practically an arm of the Insurance Department, and operates in full co-operation with that Department, and its acts all receive the approval of the Insurance Commissioner or his representative. This institution was established and is maintained by the Insurance Companies writing Workmen's Compensation Insurance, by reason of the fact that 602b of our Code requires that the Insurance Commissioner shall make and/or approve rates and classifications for Compensation Insurance which shall be adequate, and also approve various systems of rate calculation and modification. I shall refer to our two systems of individual rate modification later.

In principle the calculation of compensation rates is not particularly complicated. There are some ramifications which may be made as technical as desired, but the basic calculation depends upon taking the entire payroll of each individual classification (and there are some 750 classifications now in use in California), and the losses for each separate classification, and dividing the payroll into the losses, which gives us what we term the "pure premium", or the exact amount which it would be necessary, as applied to the payroll, to pay these losses. To complete the process, there is added those elements of overhead with which you gentlemen are thoroughly familiar, such as taxes, outside salesmen, managerial expenses, office equipment, the amount necessary to take care of claims investigations and settlements, correspondence, traveling expenses, and all of those things which are necessary to conduct any legitimate business. The result is what we term the "basic rate" for each individual classification. To each individual rate is added 1c for catastrophe. It will interest you to know that in the calculation of these rates in the event of a catastrophe, such, for instance, as that which befell the Argonaut Mine, only two average death cases are used of all the losses in each individual calamity, the balance of those losses being spread over all industry. Otherwise, the industry which had suffered the catastrophe would suffer so severe a rate penalty as to make the rate prohibitive.

The question has been asked of me whether possibly the experience of some other classification might have entered into that of a sewer construction which might influence the rate improperly, and the general answer is that each individual classification develops its own individual experience, and our classifications include only those operations which are usual and necessary in connection with the individual classificaton.

* Manager, California Inspection Rating Bureau.

As regards individual rate modifications, the Insurance Commissioner has approved two systems, the first that of Schedule Rating. This system of rate modification is impossible to apply to such work as general construction, mining, sewer building, and those other lines of construction work, the conditions of which must necessarily change from time to time. The appliances are not fixed appliances as those of a factory or a machine shop, and so you would not be interested in this particular system of rate modification.

The other system of individual rate modification is known as Experience Rating, and that is of prime importance to all types of industry. That system deals entirely with plant management, safety education and control. It has been in effect in California since 1921. The principle of this system is not particularly complicated, but is based upon the experience of any individual, co-partnership or corporation as compared to the average, as to whether the losses of the assured have been higher or lower than the average.

When you apply to your insurance carrier, the rate which is quoted will be the average rate for all concerns in your line of business, unless and until you shall have developed a sufficient premium (which is $1000 covering a period of not less than three years), and when that point is reached, your individual rate will be modified, either up or down, depending upon whether the care with which you conduct your business operations has developed less than the normal losses over your given payroll, or more than the normal losses, and at this point may I emphasize that the California Inspection Rating Bureau does not **make** Compensation **rates**; it does **make** Compensation **rate calculations**, and you gentlemen **make,** or at least **modify,** those **rates** in accordance with your losses.

May I point out that one of your great difficulties, as I see it, undoubtedly arises from the fact that many concerns enter into competition with you, who may be using your cast-off machinery, who may be endeavoring to get by without proper shoring, who may be careless as to the type of men employed, who take chances at every turn and cut corners in every possible manner. Those men, most of them, are not here present. Nevertheless, you must realize that their losses must be taken into consideration in the establishment of your rate, and it is those concerns which you should, as far as possible, seek to bring under your control.

As to what may be accomplished in the way of safety, I point to the greatest example in our experience in California, that of the cement industry, and while the cement plant is eligible for schedule rating, which I mentioned near the beginning, their greatest achievement is that of accident prevention and safety work. The rate for "Cement Manufacturing" in 1914 was $5.04 per $100 of payroll. In the present manual it is $1.82, and there are plants in California having credit rates as high as 40%, making the present rate for such plants approximately 1%. There are two cement plants in America,

one in Duluth and one in Kansas, that have passed 1000 working days with a full quota of employees without a lost-time accident.

As a further illustration of what can be done, I was informed last May by the safety engineer of a given plant in California—which plant, by the way, has the largest credit of any plant in its particular division that is permitted—that they had approximately a $9000 advantage over a competitor, in bidding on a specific contract, by reason of the difference in the rate for Compensation Insurance, the competitor having a serious debit and the plant in question a large credit.

I think I need go no further in talking to an assemblage of men of your intelligence who are earnestly seeking to improve your conditions to illustrate the advantage of safety work.

Again, the point has been raised many times of the difference in Compensation Insurance rates for given industries in the various States. There are so many ramifications in the various types of compensation laws, the legislative bodies, the administrative bodies, the type of employees, the climate—if you please—and the medical attention particularly, that such comparisons entail a vast amount of statistical research, which are all of a more or less indefinite and non-conclusive nature. However, I do have before me the rates of several States, which I give:

California	$11.36
New Jersey	12.80
Massachusetts	11.41
Texas	12.36
Michigan	15.14
Minnesota	13.89
New York	17.88

Again referring to the medical, as you know, the California law provides that in each individual accident, complete medical, surgical and hospital attention must be given until death or until complete cure has been effected, as far as is possible. We have on record one case with a total cost of $47,000; another case of $39,000 plus medical alone, and innumerable cases where the medical has run from $15,000 to $25,000, and you can visualize the case of a young man injured in a cave-in whose back is broken, in which event he may require—such cases do frequently require—a trained nurse day and night and hospital attention covering a period of years. I have with me a few cases taken at random; most of them I note are the result of cave-ins. I need not inform you that cave-ins can be and should be avoided. I will go further and advise you that on the best authority of many students of safe practices, 98% of all accidents can be avoided, and may I close by stressing the fact that no man or body of men in your employ will practice safety, unless you, as the men who are responsible for this industry, are in earnest in season and out of season in conducting your business in such a manner that accidents shall not occur, and then and only then will you be able to accomplish results. I thank you.

SEWAGE DISPOSAL IN KANSAS

By EARNEST BOYCE*

Kansas, like other states in the interior section of the United States, finds it necessary to make use of surface water as a source of municipal supply. Since all of the water courses flow through land suitable for agricultural development, it follows that all streams are more or less subject to pollution due to industrial and agricultural development of their valleys. No mountainous land is available as a catchment area for the collection of unpolluted surface water, consequently it has become necessary to give considerable attention to the problem of treating the used water of a municipality in such a way that its discharge into a stream will not create a serious burden upon the water purification plants obtaining their supplies from the same stream in the lower sections of the valley.

The importance of the streams forming the natural drainage of the state as sources of water supply has centered public interest in a sewage treatment program. Out of this public interest certain policies or theories of government have evolved. One of the most important of these policies, and one that has been enacted into statutory authority for the past fourteen years, is based upon the theory that those responsible for stream pollution do not have the right to refuse to accept their responsibility by a refusal to authorize the issuance of bonds to construct sewage treatment works. In other words, Kansas statutes provide that the governing body of second and third-class cities may, by their own action and without the consent given by a bond election, proceed with the construction of sewage treatment works and issue the necessary bonds. The theory back of this legislation is that the discharge of sewage into a stream is of more concern to the people along the valley below the city than it is to those residing within the city. It is quite possible that a serious stream pollution condition could exist and those responsible for the pollution of the stream be quite indifferent to the conditions produced below the city.

Since 1907 the State Board of Health has been given authority to investigate stream pollution, and when conditions are found detrimental to the public health, to require such changes as may be necessary to abate these conditions. Since 1927 this authority has been extended to include the investigation of stream pollution detrimental to animal and aquatic life with similar authority as to the abatement of unsatisfactory conditions. Obviously, in order to determine policies of stream usage, it is necessary for the State Board of Health to make careful investigations of stream usage and to investigate the character and nature of such stream pollution as may be occurring. Sources of pollution may be the discharge of organic or mineral industrial wastes. Some industrial wastes require considerable study in order to determine the most effective means for their disposal.

* Chief Engineer and Director, Division of Sanitation, State Board of Health, Lawrence, Kansas.

Recent legislation in Kansas has seen fit to place the cost of these investigations with the industry responsible for creation of the waste by authorizing the State Board of Health to make investigations of sources of stream pollution due to industrial wastes and to charge the cost of such investigation to the industry. So far the only special study undertaken under this new authority is the study of methods for the disposal of mineral brines produced with petroleum. This problem is being studied as a co-operative project between the United States Bureau of Mines and the State Board of Health, and the cost of this work is being paid by a very small assessment against the crude oil produced in the state. We believe that this is a very proper and equitable means of financing investigational work necessary in a study of the proper methods to be used in the disposal of these industrial wastes.

The sewage disposal situation in Kansas is definitely influenced by these two principles: first, that those responsible for stream pollution should not be given authority to refuse to finance the cost of sewage treatment by refusing to vote bond issues; and, second, that the investigational work necessary in the study of disposal methods, particularly for industrial wastes, is a proper charge to be carried by that industry.

SEWAGE DISPOSAL IN ARIZONA

By F. C. ROBERTS Jr.*

In order to present a comprehensive picture of the sewage disposal situation in Arizona, thirty-eight of our more populous communities will be considered. The population in these communities totals 190,370 out of the total state population of 435,573. These and the following figures are based entirely on the 1930 census.

The communities will be classified according to their method of disposal, and not according to the quality of the effluent produced. Some Class II plants do not produce as good effluents as do some of the Class III due to operational inefficiencies.

The six classes arbitrarily defined are presented as follows:

Class I are those plants that have screening, primary sedimentation, and aeration. Some of this class have secondary sedimentation, and some chlorinate the effluent. Of this class, there are three in the state. They serve 56,863 persons, or 13.1% of the total state population.

Plants of this class are for the most part competently and efficiently operated. Two have laboratories for control of operations.

Class II are those that have primary sedimentation with separated sludge digestion either in the separate system, or the Imhoff type. Some are without screening. There are seven such plants serving 56,099 persons, or 12.9% of the total state population.

* State Sanitary Engineer, Arizona State Board of Health.

Plants of this class are for the most part inadequately operated. Scum collection and odor conditions are noticeable in most of the Imhoff tank installations.

Class III plants are those that have septic tanks with or without screening. There are eleven such plants in the state that serve 43,315 persons, or 10% of the entire state population.

This class is the one that has caused most of the odor complaints. The tanks are usually poorly designed both as to size and hydraulics. The operator is offered no alternative in his choice of method of operating the tank.

Some of the tanks have been put in order to satisfy the city authorities. The design of the collection system has been the main objective; then the septic tank has been added as an afterthought, as a means of sewage disposal.

Class IV is chlorination only. There is one such system in the state, serving 1351 persons, or .3% of the entire state population.

This particular system has caused little trouble and is as satisfactory as could be expected.

Class V is discharge of raw sewage into some canyon or river. There are five such systems serving 23,380 of the population, or 5.3% of the total. This is the "golden opportunity" class as far as designers are concerned. It is this group that offers a possibility for the proper development of adequate disposal plants.

Class VI is the division in which the community relies on the individual disposal system. Of thirty-eight communities considered, twelve are in this classification. There are 13,441 persons in these twelve communities, or 3.0% of the total state population. Most of these places are without finances, or are not incorporated.

The balance of the population of the state, 241,124 persons, or 55.4% of the total state population, includes the great rural population of our state, found in small mining communities, outlying sections of our more populous communities, and small agricultural communities and ranches.

From these figures it would seem that our state is in need of sewage development. This is the case, although there are certain extenuating circumstances that do not make this the problem that it might be elsewhere.

As is known, the state is for most part very arid, which is to an extent a safeguard in the disposal problem. Sewage discharged into a dry canyon often disappears within a quarter mile, either absorbed by the earth or evaporated.

In considering the disposal proposition generally, it is my impression that many of the collection systems have been poorly designed or at least the public has not gotten their money's worth out of them.

For example, in one particular community the design was made for a city of about twice the size of the city at that time, or probably at any time. The system includes a large acreage of the surrounding desert. It was well constructed, but the designer was optimistic as

to the development of certain subdivisions. This was, however, probably not his responsibility, but rather that of the city authorities. As a result the city is still paying for the system and will probably be paying for it long after it has been replaced.

Another city of moderate size provided a collection system that reached to the then outside limits of the city. The collection system reached to a point but a few feet from the surface of the ground at the limits of the system. As the city has developed the interceptors have been extended to the point that they practically go over the front door step into the outlying districts. With the flat gradients resulting, velocities are so low that it has been estimated that the sewage is 6 hours old before some of it reaches the plant. This has occurred in the course of a relatively few years.

These conditions should not be charged directly to the designer, for the conditions that he was forced to meet are unknown. But as a means of eliminating some of the problems it is hoped and planned to provide for this condition through the following proposals:

In our state, in order to safeguard the public from dam failure, a State certification engineer is employed. It is his duty to inspect the construction from paper to actual accomplishment, and then to carry the inspection on indefinitely. In like manner it would seem feasible that legislation be enacted to empower the supervision of disposal plants for their competent construction and operation. The health laws of the state are lax in this respect at the present time. The only authority granted is that of ruling against the maintenance of a nuisance.

It would also seem advisable, although not usually considered in the scope of activity of a health department, to have a state board of financing, or state board of planning to prevent the over-zealous development of one particular project to the elimination of others. Public health is improved gradually by correcting all conditions, yet we have cities that are bond poor because of too great a development along one line and the community in dire need of improvement along other lines.

The question of public health in sewage disposal and other projects is too closely woven into the weave of finance to allow it to escape consideration from the viewpoint of public welfare.

The purpose of this paper is neither to praise nor to condemn the designing engineers of our state. We have highly qualified men to handle our disposal problem, but it is these same individuals that must be protected from unfair and unethical competition.

From the viewpoint of this office it is most discouraging to enter a community and discover that they have frightful sewage disposal condition and are without finances to remedy it.

SEWAGE DISPOSAL IN OREGON

By CARL E. GREEN*

The Cascade Mountains divide the State of Oregon into two separate and geographically distinct portions. The western part of the state has an average annual precipitation of about forty inches; consequently large streams are relatively numerous. The eastern portion of the state is semi-arid to arid, and has fewer streams for the disposal of wastes. These conditions are, however, somewhat balanced by the fact that the eastern section is sparsely settled.

The population of the state is over 900,000. Of this number, one-third live in Portland. The Willamette Valley is the most densely populated area in the state. The minimum flow of the Willamette River at Portland is approximately 4000 second feet.

There are 191 incorporated towns in the state. Of these, 76 have sewerage systems and 28 have sewage treatment plants. Eighteen of the smaller incorporated communities have no water systems. Necessarily, then, they would have no sewerage systems. LaGrande has the only complete treatment plant now in use. Baker has one under construction. Many of the plants in the state are septic tanks.

The first movement inaugurated to cleanse our streams was started at Salem in 1926, when an Anti-Pollution League was formed. This organization proposed drastic legislation which was defeated at the next session of the legislature. Thereafter this league ceased to function.

In the spring of 1929 the problem was again given study at the two-day Commonwealth Conference at the University of Oregon. At this meeting a State Stream Pollution Committee was organized, with the state health officer as chairman. The other groups represented on the committee were State Game Commission, State Fish Commission. League of Oregon Cities, the pulp and paper industry, the gas industry, State College, and the University of Oregon. This committee held meetings at the call of the chairman and proposed a long-time program for the elimination of stream pollution. It should be borne in mind that the elimination of pollution in Oregon is more a matter of preserving the recreational value of our streams than it is a matter of conserving public water supplies, at least at the present.

The legislature in 1932 created a State Reconstruction Advisory Board for the purpose of expediting public works projects. A revolving fund was provided for the preparation of plans and applications to R.F.C. and P.W.A. A board of consulting engineers consisting of Koon, Cunningham and Dieck made a study of the needs in the Willamette Valley and reported their findings to the advisory board and the Governor. Studies were also made of the amount and strength of wastes from all pulp and paper mills being discharged into the Willamette River. The canneries refused to co-operate in a study of

* State Sanitary Engineer, Oregon State Board of Health, Portland, Oregon.

their wastes, their contention being that in practically all instances their plants were located within incorporated cities, and that the problem, therefore, was one for the cities.

At present, Medford and Grants Pass have been given allocations by P.W.A. for the construction of treatment plants. Portland has been allocated a grant of $2,240,000 provided it can sell $6,000,000 worth of bonds to be financed by sewer service charges. Applications for loans for sewage treatment plants have been made by Burns, Salem, Oregon City and Roseburg. Lakeview and Eugene have prepared plans for treatment plants.

In conclusion it may be said that Portland, being the center of population, is the key situation for the entire state. If the Portland works are constructed, it seems logical to believe that the other cities needing sewage treatment plants will soon follow.

SEWAGE DISPOSAL IN WASHINGTON

By ROY M. HARRIS*

The need for sewage disposal plants in some portions of the State of Washington has long been apparent to sanitary engineers and public health workers.

Geographically and climatically the state is divided by the Cascade Mountains into the western portion and the eastern portion. The western portion of the state is favored by sufficient precipitation to maintain adequate stream flow throughout the year in all of the principal streams, and the concentration of population is adjacent to Puget Sound, hence sewage disposal by dilution is employed with a fair degree of success. Some trouble has been experienced by the pollution of swimming beaches, and some shellfish growing areas have been restricted because of sewage pollution. If more attention were given to the location and construction of outfalls, the dangers of shore line nuisance and swimming beach pollution could be eliminated in the Puget Sound area. From a public health viewpoint, the greatest danger of disposal by dilution in Puget Sound is the contamination of shellfish growing areas. Several small disposal plants have been constructed for the elimination of this danger, and others are needed.

Eastern Washington presents a sewage disposal problem that is entirely different from that of western Washington. This higher and more arid region has not the facilities for disposal by dilution except into fresh water streams. These streams, with the exception of the Columbia River, usually reach low stages during the summer that produce extreme pollution and nuisances. The absence of rainfall and the heavy use of water for irrigation combine to present serious stream pollution problems.

Two major streams—the Yakima River and the Spokane River—

* State Public Health Engineer, Washington State Department of Health, Seattle, Washington.

have been studied for several years, but to date no reduction in pollution and health hazards has been effected through the construction of sewage disposal plants. The Yakima River presents the most difficult problem, for the contributing sewage there is from several towns. Cle Elum, Ellensburg, and Yakima are the major offenders, with smaller towns below contributing their sewage to an already overloaded stream. The pollution problem of the Spokane River is less complex, for only Spokane contributes sewage in harmful quantities to that stream.

Although thirty-four different municipalities in the state boast of sewage treatment facilities, only one of this group can rightfully be classified as a modern sewage disposal plant. The city of Walla Walla has a modern plant employing the separate sludge digestion method with mechanically-equipped primary settling tanks, Imhoff tanks, trickling filters, secondary settling and chlorination of the effluent. Stability tests of the filter effluent show no change within twenty days, and the bacteriological quality is equal to that of the creek in which the effluent is discharged.

The total estimated cost for all needed sewers and sewage disposal plants in the state is approximately $14,000,000. Disposal plants for the twenty-four communities with greatest need would probably cost about $2,500,000, a small investment for the ensuing benefits to public health. These cities and towns are listed in the following table:

City or Town	*Public Health Reasons for Disposal*
Centralia	Pollution of Chehalis River.
Chehalis	Pollution of Chehalis River.
Cheney	Inland town with no other method of disposal. (WERA project.)
Cle Elum	Serious pollution of Yakima River.
Colville	Pollution of Colville River.
Colfax	Serious pollution of Palouse River, causing health menace and nuisance.
College Place	Pollution of wells, from small creek.
Dayton	Pollution of wells, Touchet River, and nuisance.
Ellensburg	Serious pollution of Yakima River, small creek, and wells.
Goldendale	Serious pollution of Little Klickitat River, killing of game fish, and nuisance.
Kent	Pollution of Duqamish River and wells.
Long Beach	Low, flat area produces insanitary conditions from cesspools and septic tanks.
Poulsbo	Pollution of shellfish growing areas. (To be constructed with PWA funds.)
Prosser	Pollution of Yakima River.
Roslyn	Present septic tank overloaded.
Seattle	Pollution of Lake Washington and swimming beaches.
Shelton	Pollution of shellfish growing areas. (Portion of plant completed, but not in use.)
Spokane	Serious pollution of Spokane River and injury to game fish.
Toppenish	Serious pollution of Yakima River.
Wapato	Present septic tank overloaded. Pollution of ground water.
Waitsburg	Pollution of Touchet River and wells. Present septic tank overloaded.
Winlock	Pollution of Olequa Creek and creation of nuisance.
Yakima	Serious pollution of Yakima River, irrigation waters, and ground water.
Zillah	Pollution of Yakima River.

INCINERATION OF SEWAGE SCREENINGS AT HYPERION, LOS ANGELES, CALIFORNIA

By F. A. BATTY*

In April, 1925, both the North and South Screening Plants at Hyperion were in operation. At that time only five screens in the North Plant were installed. Subsequently the additional five screens were installed and put in operation and the use of the South Plant was discontinued. The screens in the North Plant are 14 feet in diameter by 12 feet in width, having perforated slots 1/16 x 2 inches, and have a maximum capacity of 40 second feet each of sewage, about 5% of the suspended solids being removed thereby.

The Hyperion Screening Plant handles most of the sewage from the City of Los Angeles (excepting that portion of the Los Angeles Harbor), and in addition thereto the sewage from Burbank, Glendale, Vernon, Culver City, Beverly Hills, Santa Monica, Redondo, Hermosa, Manhattan and El Segundo, and a small quantity from the county.

The average flow during the period of operation has varied from a maximum of 114 m.g.d. per day to a minimum of 107 m.g.d. The flow at the present time is about 107 m.g.d. Before the incinerator was constructed, the screenings were disposed of by burying in the sand hill adjacent to the plant, trenches being excavated by an electric-driven 1-yard P. & H. dragline excavator and the screenings being covered about once daily. The screenings were discharged into the trenches through a 6-inch pipe by the use of compressed air. Although this was a very economical method of disposal, it was not altogether satisfactory. Sanitary conditions were not of the best, there being more or less odor and some fly nuisance, although screenings were periodically sprayed with chemicals. Also, this disposal was the cause of an ever-increasing difficulty, as the area adjacent to the plant was rapidly used up, making it necessary to transport the screenings a longer distance.

Various other methods of disposal were considered and finally in 1932, funds being available, incineration was decided upon. Plans and specifications were adopted and bids received therefor.

Incinerator description. Following an analysis of the bids submitted, the contract was awarded to the Morse Bougler Destructor Co. for a destructor having a capacity of 25 tons of de-watered screenings for a cost of $32,500.

The plant consists of pneumatic ejector with a capacity of 200 cu. ft. for storing wet screenings, a roll press for de-watering the screenings, a destructor having two main burning hearths equipped

* Sewer Maintenance Engineer, Los Angeles, California.

with two high-pressure oil burners of 20 gal. per hr. capacity; a stack 85 ft. in height with an inside diameter of 36 in. and the necessary instrument board, recording pyrometers and meters for recording the quantity of oil, electricity and air used. The contract did not include the building that encloses the incinerator which was constructed by the city; the automatic dry screenings weighing machine, and the water removed measuring device, which were designed and installed by the city; nor the pneumatic ejector that disposes of the ash on adjacent property.

Tests. The incinerator passed all the requirements of the 3-day official test and the 90-day trial test called for in the specifications, in a very satisfactory manner with a wide margin of safety, and on January 23, 1934, was turned over to the Sewer Maintenance Division for operation.

Operation. The screenings are raised from the pits at the rotary screens by the dewatering elevators into the small pneumatic ejectors in the screening plant and are carried by compressed air into the large pneumatic ejector at the incinerator, which has a storage capacity of 8 tons (wet) and is equipped with indicators showing when full or empty, and is operated under an air pressure of 15 lbs. The press operator, by using the sluice gate at the bottom of the ejector and other valves, regulates the flow of screenings in the hopper. As the screenings move on the slotted steel belt of the press, they are dewatered by the pressure of a series of rollers. This press is run by a 3 h.p. motor running at 675 r.p.m. and has a guaranteed capacity of 3 tons per hr.

Normally the press does not give any trouble as regards the screenings packing in between the rolls. Occasionally a few shots of wet screenings are received that contain a considerable amount of grease and these cause trouble. This condition is overcome by running the screenings through the press a little more slowly. At all other times the belt should be run full. The operator must be constantly alert to keep the press running with a proper quantity of screenings, as failure to do so seriously affects its efficiency and is immediately reflected in the oil consumption of the burner.

As the press will not handle the larger rags, etc., it was necessary to change the spacing of the bars in the automatic bar screen from two inches to one-inch spacing. This increased the quantity of coarse screenings removed, and disposed of now in the small furnace adjacent to the bar screens. Funds are available and a device for dewatering and transporting the coarse screenings directly to the charging floor of the new furnace will shortly be installed.

After leaving the end of the belt the screenings enter the weighing machine that dumps and resets automatically on receiving 100 lb. of pressed screenings. An electric counter records the number of dumps. From the weighing machine the screenings fall to a steel bin

of 8 tons capacity, the floor of which is the charging floor of the furnace.

The press at times produces more pressed screenings than the incinerator can consume. This excess varies from 200 to 1300 lb. per hour, and must be stored on the charging floor of the furnace until such time as it can be burned.

Furnace. The furnace is a rectangular structure and has upper and lower horizontal burning hearths constructed longitudinally, there being four 3-inch slots in the upper hearths. The heat from the burner and gases generated passes over the upper burning hearth, returning over the lower hearth, then under the lower hearth through the ash chamber into the combustion chamber and through the flue into the stack.

The furnace is provided with two burners, the upper burner being used for all regular burning, the lower burner being used only to start a cold furnace. The furnace is equipped with a pyrometer at the upper pass and another at the lower pass, both of which are connected to a continuous recorder which records the operating temperatures. The temperature of the upper pass runs about 1700° F. There is also a draft gauge which is kept as near .30 as possible, during operations.

Operating furnace. In operating the furnace the screenings are piled by hand adjacent to the four charging holes until 1000 lb. is stored up, then every 30 minutes the charging holes are opened and the 1000 lb. of screenings are fed into the furnace. The press operator and stoker both do this work. In starting up for the day, 2000 lb. of screenings are fed the furnace; after this the furnace is fed at a uniform rate of 1000 lb. every 30 minutes (1 ton per hour).

The screenings upon charging, fall onto the upper hearth and stoking causes the unburned or partially burned screenings to pass through the slots to the lower hearth. Continuous stoking on both hearths is necessary with rakes and slicing bars; the screenings must be turned over and over. Stoking is done at least every 5 minutes. All furnace floors at both hearths are opened one by one for this purpose. After several hours of burning it is usually necessary to remove the ash, as an excess amount of ash interferes with proper stoking. From time to time the ash contains a quantity of sand, and this must be frequently "pulled", as it causes damage to the furnace. All sand and ashes are removed from the furnace each morning and are deposited in the pneumatic ejector which is adjacent to the furnace. The ash is blown through a four-inch pipe to the top of adjacent sand hills by air pressure.

Operating. The day is divided into 3 shifts—12 midnight to 8 a.m.; 8 a.m. to 4 p.m. and 4 p.m. to midnight. Two men are required on each shift to operate the incinerator. One man is known as the press operator, to operate the several gates and valves necessary to control the flow of screenings from the ejector to the press and to

shovel the screenings near the charging holes. It is the duty of the stoker to start the burner and see that the proper temperatures are maintained, to keep the proper draft and to record on the daily operating sheet the amount of each charge and the total amount of screenings burned, also the number of gallons of oil used.

The quantity of screenings delivered to the ejector during the morning shift is small and no burning is done until sufficient screenings are on hand to keep the furnace operating continuously. Burning is usually started about 2 p.m. and completed about 5:30 a. m. the following day. This allows the morning shift time to remove and dispose of the ashes, thoroughly clean up the plant and do any repair or other work that may be necessary. The heavy stoking is done between the hours of 4 p.m. and 12 midnight.

From January 23 to June 30, 1934, 2315 tons of pressed screenings were incinerated; 45,543 gallons of oil were used. This is an average of 14.6 tons per day. (There is a tremendous variation in the quantity of screenings delivered per day, although most days run about the average.) A minimum of 6.3 tons per day and maximum of 26 tons have been delivered and burned during this operating period. (Probable cause, velocity.) There is also an unaccountable longer period variation, April averaging 16.6 tons per day.

Oil used per ton	19.7 gallons
Oil cost	97 cents per bbl.
Oil cost per ton	$.45½
Labor cost per ton	1.89
	$2.34½ (pressed)

Electricity, air, water, repairs, supervision, etc., not included.

Moisture content of wet screenings	83.5%
Moisture content of pressed screenings	65.0%
B.t.u.s per lb. of screenings (dried)	9,290
B.t.u.s per lb. of oil	19,076

Ash produced = 24 cu. ft. @ 35 lb. per cu. ft.

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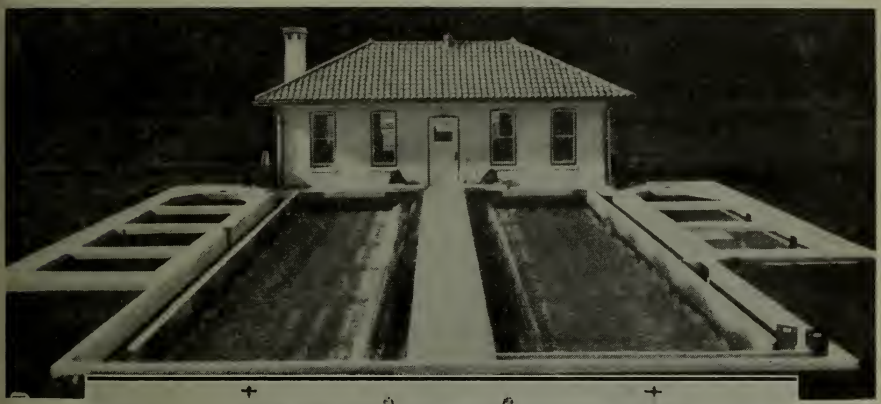
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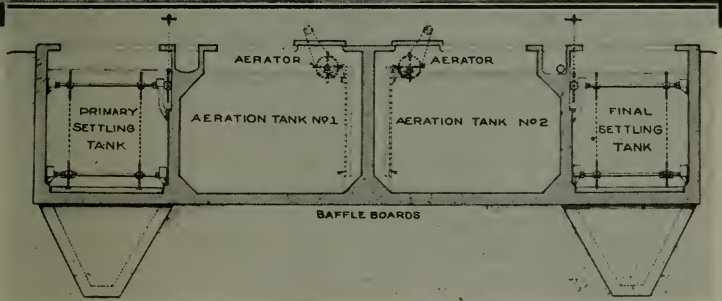
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CALIFORNIA SEWAGE WORKS JOURNAL

Official Publication of the California Sewage Works Association

Vol. VII • 1935 • No. 2

Minutes of the
Seventh Spring Conference at Fresno

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SEVENTH SPRING CONFERENCE

Fresno, April 26-27, 1935

Headquarters: Fresno Hotel

Program

FRIDAY, APRIL 26

Morning

8:00 a. m.—Meet at Hotel Fresno and proceed by caravan to inspect sewage treatment plants at Lemoore and Fresno.

Noon

12:00—Luncheon at Hotel Fresno.

Afternoon

2:00 p. m.—Papers and Discussions, Hotel Fresno.

"The Status of the Activated Sludge Patents Situation", by A. K. Warren.

"The Desirability and Feasibility of an Operators' School in California", by C. G. Gillespie, Leon B. Reynolds and Charles Gilman Hyde.

7:00 p. m.—Dinner; Hotel Fresno.

Address of Welcome by Mayor Leymel of Fresno.

Response by President T. R. Haseltine.

Presentation of Award of Merit.

SATURDAY, APRIL 27

Morning

9:00 a. m.—Papers, Discussions and Business Meeting. Hotel Fresno.

"Some Newer Application of Chlorine in Sewage Treatment", by A. C. Beyer.

"The Production and Cost of Chemical for Water and Sewage Treatment", by J. F. Smith. Discussion by R. A. Stevenson.

Noon

12:00—Luncheon; Hotel Fresno.

Afternoon

2:00 p. m.—Papers and Discussion; Hotel Fresno.

"The Probable Field of Chemical Treatment of Sewage", by R. F. Goudey. Discussion by B. D. Phelps and R. A. Stevenson.

"A Venturi-Type of Metering Station for Sewers", by H. K. Palmer and F. D. Bowlus.

Resolution Adopted at the Fresno Spring Conference 1935

Whereas, within the past month the California Sewage Works Association has lost from its membership by accidental death **Olin E. Steward,** a beloved and respected member,

And Whereas, he was active in our affairs as a member of the organizing committee of this Association, served on several committees, regularly attended our conferences and conventions and took a prominent part in our deliberations,

Now, therefore, be it resolved that this Association expresses its regret at the untimely death of our friend and fellow member **Olin E. Steward** and directs that this resolution be spread upon its minutes and a copy thereof be sent to the bereaved family.

MINUTES OF SEVENTH ANNUAL SPRING CONFERENCE, CALIFORNIA SEWAGE WORKS ASSOCIATION

The Seventh Annual Spring Conference of the California Sewage Works Association was held at Fresno, California, April 26 and 27, 1935. Eighty-five members and guests were in attendance. Headquarters were established at the Fresno Hotel.

On Friday morning a caravan took the members and guests to visit the Fresno and Lemoore sewage disposal works. Both plants were using only the plain sedimentation treatment process. The sewage from Fresno amounts to about 12 m.g.d. dry weather flow. The Lemoore sewage is unmeasured. Fresno has recently constructed a large presettling basin to remove sand, silt and a large quantity of raisin seeds.

After an informal luncheon at the Fresno Hotel the meeting was called to order at 2:00 p. m. by President Haseltine, and the scheduled papers were read. Time was permitted for considerable discussion of each paper.

Seventy-five members and guests of the Association assembled at 7:00 p. m. for the dinner meeting. After thanking the local committee on arrangements for the conference, President Haseltine introduced this committee, including their wives who had pleasantly entertained the visiting ladies during the afternoon. The President then turned the meeting over to Frank Rantsma, chairman of this committee. Several delightful songs were presented by a trio composed of a soloist, pianist and violinist, all members of the Fresno City Department of Public Works.

Owing to the illness of Mayor Leymel, City Engineer Vincenz of Fresno gave the address of welcome. President Haseltine responded. He particularly took stock of the C.S.W.A. affairs during the past seven years of its existence.

Prof. Leon B. Reynolds presented the report of the committee on Award of Merit for 1934, and owing to the lack of interest on the part of cities and districts no award was made.

The final session of the conference was held on Saturday, the meeting being called to order by President Haseltine at 9:00 a. m. After the scheduled papers were read and discussed, the President announced the appointment of a committee on Operators' Schools, composed of H. F. Gray, chairman, F. A. Batty, A. P. Banta, John Jacobson and A. B. Shearer, who are to report at the next meeting of the Association.

It was announced that the Eighth Annual Meeting would be held in Palo Alto on September 23rd and in San Francisco with the Leagues of Municipalities on September 24th.

The conference was brought to a close by passing a resolution of sympathy, a copy of which was ordered transmitted to Mrs. O. E. Steward of Anaheim, whose husband was recently killed in an accident. Mr. Steward had always contributed much to the affairs of the Association.

Respectfully submitted,

FRED D. BOWLUS,
Secretary-Treasurer.

THE STATUS OF ACTIVATED SLUDGE LITIGATION IN CALIFORNIA

By A. K. WARREN*

On February 7, 1933, the United States District Court determined four patents, owned by Activated Sludge, Inc., to be valid and infringed by the city of Milwaukee in the construction and operation of the Milwaukee activated sludge sewage treatment plant. Subsequently the decision was unanimously affirmed by the three judges of the United States Circuit Court of Appeals on Mar. 2, 1934. Petition for review was denied by the United States Supreme Court on Oct. 8, 1934. On Oct. 18, 1934, the Courts held that the Sanitary District of Chicago had infringed the patents involved in the Milwaukee suit and also one other relating to spiral flow.

Prior to and after these decisions were rendered, the owners of the patents, Activated Sludge, Inc., notified the activated sludge plant owners in and about California that they were infringing and demanded settlements of their claims for royalties for infringement. The plants in California, as well as practically all others in the United States, awaited the outcome of the Milwaukee trial and its appeals before offering settlement or compromise.

The five patents which have been validated are numbered and briefly described as follows:

No. 1,247,540: This patent describes the process of treating sewage and the like by causing local up-flow in the liquid, supplying air thereto, and causing the sewage to flow to the point of application of the air; also removing the clarified liquid in the body of the sewage. It is further described as causing an up and down flow and a lateral flow in the liquid, returning the sludge to the up-flow; also, as introducing air locally at a plurality of points and of delivering locally to the lower portion of the sewage a plurality of successive increments of infusions of minute bubbles of air, causing the sewage to so come under the influence of succeeding increments of air.

No. 1,247,542: This relates to the return of sludge to the incoming mass of sewage and to its aeration and oxidation, and the subsidence and removal of sludge in the final clarifiers.

No. 1,282,587 consists of the purification of sewage in a tank supplied with means for introducing air or oxygen at the lower portion of the tank, causing the mixed liquor or sewage to rise and circulate.

No. 15,140 is a re-issue of No. 1,247,543 and relates to the process of purifying sewage by combining crude sewage and bacterial sludge, aerating or oxidizing it and allowing the sludge to subside, permitting the withdrawal of effluent from the surface. It also describes the re-aeration of activated sludge and the return

* Chief Engineer and General Manager, Los Angeles County Sanitation Districts.

of re-aerated sludge to the incoming sewage prior to aeration.

No. 1,286,017 is a process patent which appears to define more specifically than the earlier ones the use of the "activated sludge in the treatment of sewage".

Activated Sludge, Inc. claims to be the owner of eight other patents relating to the activated sludge process and production of fertilizer therefrom, but as these patents have not been validated in the courts and because evidence upon them, as well as upon those which have been validated, is so confusing that nothing short of a court decree could establish their validity, they were not considered as important in connection with the settlements effected by California communities.

The suit against the city of Milwaukee by Activated Sludge, Inc. was filed on June 15, 1928, citing six patents and claiming infringement of forty-one claims. Prior to this time, the suit had been brought against the city of Chicago for infringement of six patents and twenty claims. During the trials, depositions in excess of two thousand printed pages and exhibits totalling upwards of two thousand sheets were presented in court. Much of the testimony in the form of depositions had to be gathered in England, while in this country a large group of individuals, including members of the California Sewage Works Association, gave testimony in the defense of both the Chicago and Milwaukee suits. In spite of a doubt which existed in the minds of the defendants, the decisions rendered in the case of Chicago and Milwaukee appeared to be sufficiently conclusive to warrant a settlement of other claims rather than to attempt further and expensive litigation with an exceedingly doubtful outcome.

Speaking before the Sanitary Group of the Los Angeles Section of the Am. Soc. C. E., Mr. Leonard Lyon, patent attorney, related that as of Jan. 30, 1935, Activated Sludge, Inc. had filed suits against more than one hundred cities and official bodies in the United States and that nearly one-half of those against whom action was taken had made monetary settlement. A number, including some cities in Texas, had decided to contest the suits as of the date of his discussion, but by this time more have probably settled. Judgment in the case of Chicago may involve nearly $1,000,000, and at Milwaukee nearly $500,000 is asked. These rather unusual sums are requested by Activated Sludge, Inc. because of the excessive cost of litigation. The costs are expected to amount to about $1 per capita in each of the two cities. Damages asked are usually for past infringement, as a number of the patents have already expired and all, excepting one renewal which has not been adjudicated, will expire by the latter part of 1937.

The list of eastern cities and towns which have made settlement with Activated Sludge, Inc. includes Cleveland, Indianapolis and a number of others of like import.

Suit was instituted against the city of Tulare, Calif., on Aug. 28, 1934, by Activated Sludge, Inc., seeking an injunction restraining further use of the activated sludge plant and asking for damages and an accounting. Suits against the cities of Pasadena, Ontario, Pomona, San Marino, Laguna Beach, Escondido, the Los Angeles County San-

itation Districts and others followed rapidly. Two of the communities against which action was taken denied that they were using the activated sludge process, which had been discontinued as impractical and too expensive to meet their needs. A number made immediate settlement, including San Francisco, Laguna Beach and Ontario.

Pasadena and Pomona first considered defending the suits, but after a state-wide investigation of the status of suits and claims made by the Committee of the California Sewage Works Association, determined to effect a compromise, in which they were joined by the Los Angeles County Sanitation Districts, with the result that the damages paid by the three plants were less than half of the amount originally indicated by Activated Sludge, Inc.

Immediately upon the appointment of the committee by the Sewage Works Association*, its chairman, the author of this paper, contacted all of the cities in the State of California known to be involved in litigation and elsewhere that there was a likelihood of suit being instituted. Responses to the inquiry of the chairman were prompt. It was learned that Pasadena, Pomona and the Districts were the only three claims remaining unsettled and which there was a hope of Activated Sludge, Inc. collecting. A communication to the city of Phoenix, Arizona, disclosed that that plant had paid the company $15,000, and information from Texas indicated that a number of Texas cities had settled and that those which had not, had already made such arrangements as were required for defense or compromise.

It is believed by the Sewage Works Association committee that the united front presented by the three largest Southern California plants is entirely responsible for the large monetary saving for each. The amounts paid or to be paid for the patent rights and damages for these three plants are as follows:

Pasadena	$20,321.00
Los Angeles County Sanitation Districts	8,375.00
Pomona	2,025.00

These are considerably less than the sums asked or the sums set out in the schedule for payments, depending upon the date of infringement, by Activated Sludge, Inc., and are the result of an offer from the company to the three districts to the effect that the above stipulated sums were to be paid in event the action was not contested by any of them and was to be increased proportionately if the suit was defended.

Apparently the activated sludge difficulties are settled so far as existing plants in California are concerned. Plants constructed after the close of 1935-36 will doubtless be free of any royalty payments because of expiration of patent rights. It can not be said that the royalties asked by the plaintiffs, Activated Sludge, Inc., are prohibitive, for, in fact, the contrary is true. On the basis of payments in California the amounts paid as royalties will have little effect upon the annual per capita cost for sewage treatment. Unless the decision with respect to Chicago is reversed or a plant in another judicial dis-

*Committee members: C. C. Kennedy, A. W. Wyman and A. K. Warren, chairman.

trict elects to defend the suit and is successful in obtaining a reversal of the decisions rendered in the Chicago and Milwaukee cases, and through such means succeeds in carrying the case to the Supreme Court and having the decisions all reversed, finding for the defendants instead of the plaintiffs, California communities can consider themselves well-off with respect to charges and payments to Activated Sludge, Inc. and can likewise congratulate themselves upon not having had to spend such relative sums of money in litigation as have been expended by both Chicago and Milwaukee.*

T. R. Haseltine: "I would like to know if the newest or latest patent expired in 1927?"

A. M. Rawn: "There is one patent which has not, to my knowledge, been validated, which expires in 1950. The latest valid patent, so far as I know, expires in 1937."

C. G. Gillespie: "When does the fertilizer patent expire?"

A. M. Rawn: "Patent No. 1,294,000—this patent is not known by the speaker to have been adjudicated. It was issued on February 11, 1919, and the expiration date is February 11, 1936. So far as the terms of settlement in California are concerned, it makes little difference excepting to those who contemplate new construction—just when the patent does expire or did expire. If it was validated and held valid during the past few years, even though it has expired, the individual infringing is liable."

W. T. Knowlton: "Do the patents cover the activated sludge process of treating foul liquors as well as sewage?"

A. M. Rawn: "They seem to be rather all-inclusive, covering sewage and other foul liquors as well as sludge which is sometimes called muck or sediment. Anticipating a possible question, I wish to state that it is my understanding that the activated sludge patents were validated upon their strength as apparatus patents and not so much as process patents. The differentiation is not quite clear to me because in reading the descriptions validated in the Chicago and Milwaukee suits, it would appear that part of them are process patents and part apparatus patents."

*The above paper was not completed at the time of the Fresno meeting, but a review of the situation was presented by A. M. Rawn.

THE DEVELOPMENT AND FUNCTIONING OF SHORT SCHOOLS FOR OPERATORS

By LEON B. REYNOLDS*

When the question of the desirability and feasibility of an operators' school in California was presented to me, the immediate query raised in my mind was concerning the success of similar schools in other states. As Cervantes wrote in Don Quixote, "the proof of the pudding is in the eating," a test appropriate for water operators but of doubtful expediency for operators of most sewage plants. Knowing that operators' schools existed in the East but lacking exact information as to their number and location, the first step seemed to be to find a list, which was attempted without success. Occasional reports and programs of some such schools were, however, found in the technical publications.

In order to get more complete information it seemed necessary to correspond with officers of organizations, engineers and professors. Nearly 60 letters were sent to 48 people in 26 different states with an outline of the information desired. All of the 16 state associations which are members of the national federation were included. Despite the well-nigh universal dislike of questionnaires, 87 per cent replied and all 26 states were represented, an unusual response which deserves a special expression of appreciation. A considerable mass of data and opinions was secured, which this paper will attempt to summarize.

It was found somewhat difficult in some cases, especially in the lack of actual programs, to distinguish between instructional schools and conventions or conferences. The name adopted does not necessarily indicate the real character of the meetings. In some states there are schools for sewage works operators alone and in other states schools for water and sewage plant operators together are held. In some states there are schools for waterworks operators alone. The following lists do not purport to be complete but are probably more nearly so for sewage operators' schools than for waterworks operators' schools.

Sewage Works Operators' Schools: Michigan, New Jersey, New York, Pennsylvania, Wisconsin 5

Water and Sewage Works Operators' Schools: Georgia, Kansas, Maryland, Delaware, Missouri, Oklahoma, Texas 7

Water Works Operators' Schools: Florida, Indiana, Michigan, Montana, New England, New Jersey, North Carolina, Tennessee, Virginia, Wisconsin 10

Our interest lies primarily in the schools providing instruction for the sewage works operators, although the experience with schools for waterworks operators may be indicative of probable experience with schools for sewage works operators.

History

Credit should undoubtedly go to V. M. Ehlers, State Sanitary Engineer of Texas, for organizing the first short school for operators and

*Professor of Sanitary Engineering, Stanford University.

starting the movement which has since spread into more than one-third of the states. The first school in Texas lasted one week. General lectures and laboratory work in bacteriological and chemical testing of water were given to the five water plant operators who attended. By 1922 the school had become a convention, meeting in various cities and attended by engineers, salesmen, commissioners, and superintendents as well as plant operators. Technical papers occupied a day or two and the school portion, devoted to laboratory work, mostly demonstrations of standard tests, occupied a day or two. As time went on, increasing attention was paid to sewage. While most of the Texas meetings seem to have been convention-dominated, the 1929 session was a real school at A and M College, extending over ten days with the last two days devoted to the usual convention. Thirty plant operators and superintendents attended and had actual practice in laboratory, interspersed with lectures by members of the college faculty. Operators having sewage plants were given special instruction. It is planned to make the eighteenth short course next January another real school. Kansas in 1921, Oklahoma in 1925, and New Jersey in 1927 were the first three states to follow the lead of Texas.

Schools for Sewage Works Operators

There are now at least five schools for sewage works operators alone, as follows, with dates of their first sessions: New Jersey (1927), New York (1931), Michigan (1932), Wisconsin (1933), Pennsylvania (1935). In Iowa the annual Sewage Works Conference at State College lasting three days has devoted parts of two afternoons to laboratory demonstrations and practice of standard tests; the remainder of the program seems to be of the convention type. All have been meeting annually, sometime during the first four months of the year, except New York, which has met three times in five years. In general these schools have been sponsored by the State Sewage Works Association and State Board of Health; in New York also by the State Conference of Mayors through the Municipal Training Institute, incorporated by the Mayors' Conference and chartered by the university regents to conduct training schools for municipal officials; in Wisconsin also by the League of Municipalities.

With the exception of the New York school held this month (April, 1935) at the State Office Building in Albany, all schools have been held at some college or university as follows: New Jersey, at Rutgers and the State University; New York, at Union College and Cornell; Michigan, at State College; Wisconsin, at State University; Pennsylvania, at State College. Engineering, bacteriology and other departments of these institutions have cooperated. In Michigan the instructors are drawn from the college faculty and in the other states college professors have been assisted by engineers of the State Board of Health, consulting engineers, sales engineers, prominent operators and city officials.

In every case the school is separate from the convention of the Sewage Works Association; in Michigan the school is followed by the two-day convention. The New Jersey School lasts eleven days, the

Wisconsin and Pennsylvania Schools five days, and the Michigan and New York Schools three days (the two former New York Schools lasted five and one-half days). The tuition fees charged are as follows: New Jersey $15 (with an additional $2 for trips and $0.50 for books); Wisconsin $10 (with additional $15 estimated for living expenses); Pennsylvania $6 (with $2 for text book and $7.50 for living expenses); New York none this year (financed by Mayors' Conference), formerly $5 and $10); Michigan, no fee.

The registration at these schools will be of interest. In New Jersey the attendance has been from 16 to 28, averaging about 21 with a tendency for a certain number to come back in successive years for advanced courses. During the six-year period, 1927-1932, 70 per cent were plant operators and superintendents, 26 per cent were connected with equipment companies, 4 per cent were outsiders. In New York the first two schools were limited to 25, and the third school, of somewhat different character, this year had an attendance of 75. In Michigan the attendance for four years has averaged 25 with many repeaters. In Wisconsin the registration has averaged 18 with some repeaters. In Pennsylvania the registration for the first school this year was limited to 15 and the actual number attending was 11.

The content of the curriculum and the method of instruction vary in the different schools. The Pennsylvania School, recently held for the first time, consisted mostly of laboratory work in chemistry, bacteriology and hydraulics, with a minimum of lectures. The Michigan curriculum deals exclusively with laboratory procedure in chemistry and bacteriology with incidental lectures on the tests; the work is divided into four groups in an attempt to satisfy the desires and qualifications of those attending. The entire time of a student is taken by the work in one group only, and by regular attendance it is possible for an operator to complete the entire curriculum in four years. A class in hydraulics is also offered. The work is individual whenever possible. The New Jersey School devotes 35 per cent of the time to general lectures and discussions, 45 per cent to laboratory exercises and demonstrations, and 20 per cent to inspection trips. For the benefit of students desiring to continue in advanced studies, three courses in all are available.

The programs for the first two New York Schools included lectures, demonstrations and laboratory practice, utilizing college laboratory facilities. The school this year consisted of lectures and demonstrations only, but the Board of Health is hopeful that some college having the proper facilities will again undertake a school with intensive laboratory practice. The demand for the laboratory type of school was expected to be determined at this year's session. A simple true and false test has been used to determine how well the information was assimilated and to serve as a basis for a round table discussion at the end of the course. Instruction at the Wisconsin School is divided into lectures (abstracts being furnished the students) and demonstrations during the five forenoons and laboratory practice by the men themselves in the afternoons in the manner of university

classroom procedure. The laboratory work is in two sections, one for those attending for the first time and one for those having attended previous schools. The last day has an open period for round table discussion and quizzing for those attending.

Some sort of certificate is awarded to each student at each school, usually a certificate of attendance. In Michigan the certificate is given to each one satisfactorily completing the work; and definite completion and report on results are required for credit toward a certificate. In Wisconsin the certificates of accomplishment are presented at a dinner held at the conclusion of the school. In New Jersey an examination is given and satisfactory completion of the course is based upon attaining a passing grade.

The rules and regulations governing issuance of licenses to sewage plant operators in New Jersey, adopted by the State Department of Health in 1936, set out certain qualifications for admission to the examinations and credit is given to an applicant for his attendance and satisfactory completion of the short courses. In Michigan the completion of the course adds to the qualifications for taking the examination for a certificate as a plant operator. In Pennsylvania there was some agitation this year to secure a licensing act, but the proposition was voted against by the Water Works Operators' Association and the Sewage Works Association decided not to attempt to get a separate act for sewage operators. In Wisconsin committees of sewage works operators and water works operators were appointed during this year's schools to assist in developing suitable licensing procedure to be put in effect within the next two years. There are no licensing provisions in New York but the hope exists that attendance at the school may become a prior requisite for issuance of licenses.

The testimony of the state sanitary engineers concerning the schools may be of interest. Edward D. Rich of Michigan writes: "We feel that this school is useful for all classes of operators because the teachers are sufficiently associated with actual practice to make the course a very practical one and well adapted to field conditions." C. A. Holmquist of New York says: "The enrollment has included a wide range from the ordinary non-technical small plant operator to assistants of consulting engineers, but the programs have been designed so that even the non-technical man can benefit. We know that these schools have been of great value to the operator himself and to the municipality and the state. There has been a definite improvement in plant operation following attendance at such schools and the installation of laboratory equipment and keeping of operating records has been especially gratifying. The schools have done much to enhance the dignity of the profession and instill a certain amount of pride and interest of the operator in his plant." L. F. Warrick of Wisconsin: "The course has been intended primarily for the semi-technical operator. The school was started as an initial step toward bettering the status of operators and to provide them with such information as will assure most efficient and economical operation of their plants,

thereby promoting public health and welfare." H. E. Moses of Pennsylvania writes: "I consider that such schools are distinctly advisable since by these intensive courses the operators will receive instructions impossible to be given during annual conferences of the various associations. The cost should be moderate so as to put the course within the reach of these men, many of whom would be unable to pay a large sum."

Several comments regarding the need or plans for schools in other states may also be pertinent. B. A. Poole, State Sanitary Engineer of Indiana, reports: "We will probably hold our first sewage treatment plant operators' school next year." Harvey E. Holmes, Assistant Sanitary Engineer of Massachusetts, says: "A school for instruction of sewage work operators would be most desirable in this state." H. B. Foote, Director of Montana Division of Water and Sewage, writes: "Where sewage treatment is advanced to a point where mechanical equipment is required and secondary treatment is practical, I believe that a short course for operators would be of great benefit." Louva G. Lenert, Chairman of Florida Section, A.W.W.A., says: "I think it is but a matter of time before the Florida School will also include instructions on sewage treatment, as this is greatly needed."

Schools for Water and Sewage Plant Operators

Schools for water and sewage plant operators jointly have been held in the following six states, the date being that of the first school: Texas (1919), Kansas (1921), Oklahoma (1925), Missouri (1930), Georgia (1932), Maryland (1935). In addition an attempt has just been made to organize such a school in South Dakota, but it cannot be said to be a going concern yet. These schools are in general sponsored by State Water and Sewage Works Associations, State Departments of Health, in the case of Texas by the Texas Division, Southwest Water Works Association, and in the case of Kansas by the University as an extension activity.

The location of the schools varies: in Texas the non-convention-dominated sessions have been held at the University, or A & M College; in Kansas the school is always at the University; in Oklahoma at A & M College; in Missouri at the University; in Georgia at the School of Technology; in Maryland at Johns Hopkins, Baltimore plant laboratories and State Department of Health office.

The instructors, method of presentation, and subjects covered vary greatly in the different schools. In Texas, as already explained, most of the sessions have been held at cities which made the invitation at the instigation of local water departments and often the convention features dominated over the school side. Sections permitting different types of instruction for beginners and more advanced students have been used sometimes, but the limited time available prevented any very effective specialization. The school has often been conducted in parallel sections for water and sewage with a single laboratory section in the afternoons and inspection trips occasionally.

In Kansas the curriculum consists of lectures with demonstrations

and actual practice depending upon the subject presented. Many take advantage of the opportunity given for any operator to make such tests as he is interested in at the State Water Laboratory under supervision of the laboratory personnel. About one-sixth of the total school time is spent on sewage. The program is supposedly arranged largely for the benefit of the non-technical operator, and the speakers are drawn from various sources. The school is held in conjunction with the annual convention of the Kansas Water and Sewage Works Association; only two years have been missed since 1921.

The Oklahoma Short Course is held separately from the Water and Sewage Conference. Recent programs include one day of lectures, two days of chemistry laboratory and two days of trips; formerly lectures occupied three days and laboratory and class work two days, with the inspection trips prior to the school. Only one short course has been held in Missouri, in 1930; the morning sessions were devoted to laboratory work and the afternoon sessions to lectures.

The Georgia Short School advertises its purpose as instruction in the practical control of water and sewage plants including physical, chemical and bacteriological tests with opportunity for each operator to perform the basic control tests in the laboratory, adjustments being made to fit the individual needs of those attending. The training has actually included lectures, demonstrations and laboratory practice; future plans include plant visits and observation tours. The school is held at the same time as the meeting of the Water and Sewage Works Operators' Association, but a minimum of social activities is scheduled, as both day and night sessions are needed for training work.

The first Maryland-Delaware Short School was held in February of this year, separate from the Water and Sewerage Association. The first day was devoted to water problems and the second to sewage problems and one evening session dealt with both. Morning discussions were held in the office of the State Department of Health, afternoon demonstrations at one of the Baltimore plant laboratories and the evening session at John Hopkins.

All of the six combination schools meet annually, with the exception of Missouri, which has not met since 1930. No tuition fee is charged except in Texas and Oklahoma, where it is $1.50. In Kansas the University originally appropriated $250 a year to cover the cost of printing and travel expenses of a few outside speakers; more recently the annual dues of the Water and Sewage Works Association and the funds of the State Water Laboratory are used. The attendance as of the last meeting has been much larger than at the strictly sewage schools, as follows: Texas 175, Kansas 135, Oklahoma 60 (of which half are repeaters), Missouri 120, Georgia 140 (a great majority being actual operators who attend repeatedly), Maryland-Delaware 63. The length of the last course was as follows: Texas 3 days (7 in 1919, 10 in 1929), Kansas 3, Oklahoma 5, Missouri 4, Georgia 2½ (will be 4 henceforth), Maryland-Delaware 2.

In Texas a certificate has been awarded to each attendant after passing an examination. In Kansas no examination is given nor cer-

tificate issued. In Oklahoma, in 1932, 16 of the 85 in attendance completed forty hours' instruction and received certificates from the State Department of Vocational Education. In Georgia upon request of the association a written examination was given at the conclusion of the school and a class C certificate was granted to 65 operators; future schools will provide opportunity for examination for advancement to classes B and A. In Maryland-Delaware certificates of attendance were issued.

State licensing of plant operators is not in effect in any of the states having combined schools. The matter of licensing has been given some discussion in Kansas. In Oklahoma there is now a licensing bill before the legislature. Georgia has no licensing law at present but attention is being paid to the matter with the prospect that some law will be passed within the next two years; it has been pointed out to operators that their own certification based on recognized qualifications will put them in a position to secure licenses in the future when they become necessary.

In Texas during the past few years there has been much discussion of the future of the school, in general leading to one of two conclusions: (1) abandonment of the school entirely, (2) complete separation of the school from the convention. The proponents of abandonment urge the uselessness of bothering with the non-technical operator or small-town superintendent and the desirability of placing technical graduates in operators' positions. The proponents of continuation, without connection with the convention, admit the desirability of technical graduates but point out the hopelessness of trained men being employed by very many small towns, the dangers involved in the service of men having no knowledge of their responsibilities, and the desirability of instruction being given to as many as can be persuaded to take it.

Earnest Boyce, State Sanitary Engineer of Kansas, writes: "Our program is arranged pretty largely for the benefit of the non-technical operator. We believe there is a permanent need for the type of instruction being given." W. H. Weir, Assistant Chief of the Georgia Division of Sanitary Engineering, says: "The time devoted by the personnel of our division to reorganizing and carrying on the short school has been most profitably invested." Edward S. Hopkins, of the Baltimore Department of Public Works, writes: "Subsequent discussion indicates that considerable help was obtained from the demonstrations. It is believed that a new viewpoint was given to many operators as to the meaning of plant control. The school was arranged for the non-technical worker and we believe it was successful."

Schools For Water Plant Operators

Schools for water plant operators separately have been held in a number of states, including those mentioned and probably others. The New England Water Works Association has conducted four water works schools of 3 days' duration in various localities of New England. Quite a number of state sections of the American Water

Works Association also have schools, including the following: Florida (3 days), Indiana (1), Michigan (3), Montana (2), New Jersey (11), North Carolina (3), Tennessee (5), Virginia, by zones (2), Wisconsin (5).

In general, these schools are separate from the convention of the section (exception, Florida) and in some cases the convention is held immediately following the school. In Indiana a new scheme has been adopted; the state has been divided into eight districts so that a drive of not more than 60 miles will be required and an annual one-day school will be held in each district.

Summary

The development, functioning and present status of schools for operators have been delineated as completely and accurately as the available data permitted and the time available justified. Five schools strictly for sewage plant operators, six schools for water and sewage plant operators, and ten schools strictly for water plant operators, have been considered. It may certainly be said that the number of such schools and the interest in such schools is on the increase throughout the Middle West and the East.

The interest of the California Sewage Works Association probably lies primarily in a school strictly for sewage works operators, although a joint school for water and sewage plant operators might appeal to some. From the data outlined herein, it may now be possible to make certain observations about the average or typical school. Such a school would be sponsored by the Sewage Works Association and State Board of Health and would meet annually, separate from the convention of the association. The school might take the place of the spring conference or be followed by the conference. It would meet at one of the universities and the instructors would be drawn from the university faculties and the personnel of the State Board of Health, with some assistance from the consulting engineers and the more capable operators. The school would emphasize actual laboratory practice and methods of operation and would be conducted in a manner approaching that of university class room procedure. It would last from three to five days, draw perhaps twenty students and cost $5-$10 for tuition. At the conclusion, certificates of attendance, or possibly certificates of performance based on examination, would be awarded.

You are all familiar with the story of the ambitious rooster who paraded his harem of loyal hens before the ostrich egg as an object lesson as to results in other communities. It now remains to be seen whether my discussion colleagues and you members consider the object lesson to be worthy or possible of accomplishment.

AN OPERATORS' SCHOOL IN CALIFORNIA

By C. G. GILLESPIE*

Until 1916 or thereabouts, the only sewage treatment works in California were simple septic tanks and Imhoff tanks and there were not over a half dozen water treatment plants. The operators did not know the functions or operating procedure of their plants. To illustrate by a true story, one operator, who had a new chlorinator, greeted us with the remark, "Tell me something about this thing. I have come down from Oregon where the only trouble they have with water is keeping it out of the milk." So you see there was need for an operators' short school even then.

In the years that have elapsed, the Bureau of Sanitary Engineering gradually supplied much of the instruction the operators needed and did it in perhaps the ideal way; viz., by visits to the individual operator at his own plant, where only those things that pertained to his problems were given him. In this way the bureau became an excellent clearing house for valuable operating ideas which it would pick up at one place and leave at another. It is impossible to over-estimate how far these little influences have traveled.

In the course of the years. however, the number of sanitary works has increased in California to such an extent and state finances have so shrunk that it is no longer possible for the bureau to keep contact with individual operators. At the present time we depend very largely on such group meetings as this to keep advised on the operators' problems. A recent compilation that is reasonably accurate, shows there are in the state over 600 installations of sewage or water treatment units. In this compilation a plant having an Imhoff tank and sprinkling filter has two "units" of treatment. A total of 422 of the units are for treating sewage and they utilize two distinct processes. There are approximately 200 water treatment units representing 9 different schemes of treatment. There are fully 250 superintendents who operate these works.

The sanitary engineering works are classified as follows: 101 Imhoff tanks, 96 septic tanks, 31 primary sedimentation tanks, 43 trickling filters, 12 activated sludge plants, 2 contact beds, 46 secondary settling tanks, 11 sand filters, 30 sewage chlorinators, 36 separate sludge digestors—14 of which collect gases and 9 utilize the gases. There are 24 water supply systems having large reservoirs, 24 systems that use water coagulation, 10 have pressure filters, 10 have gravity rapid sand filters, 2 have slow sand filters, 80 chlorinate the water, 22 use ammonia and at least 2 use activated carbon and 4 use lime. It is estimated that there are 211 separate sewage treatment

*Chief, Bureau of Sanitary Engineering, California State Department of Public Health.

plants and hence that number of superintendents. There are at least 82 water treatment plant superintendents. In some cases the same man is both water works and sewage works operator. This list may afford some indication of the field for different kind of instruction an operators' short school might offer.

The desire for information by operators is undoubtedly greater now than it was 20 years ago. There are more plants and a greater number of operators. Plants are of greater diversity of function and design and processes are more refined and delicate. The public is becoming more exacting and every operator has to be on his toes. Then, too, there is the new crop of layman operators always coming on.

On the other hand, there is the endless output of science and discovery which is going ahead by leaps and bounds, bringing out new theories, new ideas and new processes in sanitary science as in other interests of life. There is, therefore, always the problem of bringing these new developments to the notice of operators and engineers who apply them. Many revolutionary discoveries in the research laboratory of the pure scientist have lain dormant for decades or generations until accidentally discovered by others who had a sense of application and appreciation of the usefulness of the ideas. Take for example the activated sludge process and the colloid theory which underlies most clarification problems in water and sewage.

To serve the purpose of bringing needed and useful ideas to the operator, there are at present the various conventions and conferences, the technical and trade journals, the bulletins of various universities, State Boards of Public Health, U. S. Public Health Service, and other Federal Divisions. Our bureau still has some field contact with the operators, but of greater importance nowadays are the field representatives of the various firms which handle sanitary engineering equipment.

The group meetings of the various sewage works and water works associations and various publications have been of tremendous value. In California we have our own Sewage Works Association which is attended by a hundred or more at each session, many of whom are plant superintendents. The water purification division of the American Water Works Association is another strong and lively group in California. But in neither case can the meetings strictly be termed a "school." The papers and discussions are planned to suit the largest attendance and mainly to describe new plants and bring out new developments. The programs are not organized for progessive education as is a course of educational instruction. Many who attend the conventions and conferences must feel like a pupil who is forced to skip the first grade and land directly in an upper class. Only a prodigy could hold his own under such circumstances.

As yet, the tendency toward employment of sanitary chemists and sanitary engineers in the operating field has not been conspicuous and therefore has not filled the gap that is engaging our attention today. The plans of many of the consulting engineering firms to organize a supervisory service for operation, has likewise not borne fruit. As a

comment it strikes me as being a mighty good idea providing a high calibre sanitary chemist or sanitary engineer were used for the purpose, one who is expert in a wide range of water purification and sewage treatment problems. I presume the main obstacle is the charge that would have to be made to support a high class service and give sufficiently frequent visits over the range of territory he would have to cover.

Though there are many who feel that the operation of these sanitary works should go to the college trained man, I think it is inevitable that the great majority of operators will always be laymen. It does not follow that because the task involves dealing with complicated forces, only those thoroughly familiar with the sciences involved can do the work. Mechanical, electrical and chemical industries are quite as abstruse as sanitary engineering, but think of the army of men at work in them who probably had nothing more than some grammar school education.

But even the college trained operator, the engineers and sanitarians are good potential attendance at such a school. For them rather more advanced course should be available. Of course this makes the planning and conduct of a school of such short duration quite a task. To avoid duplication of the conventions and conferences, in my opinion, it is essential the operators' short school include not only laboratory demonstration but laboratory experience by those attending. There should be explanatory lectures of both laboratory procedure and interpretation of results, elementary description of sewage treatment processes and talks on the latest research. Thus both laboratory and lecture room must satisfy a wide range of interests, and if water works men attend, the school must be still further broadened. To crowd all this into the short space of a week or ten days is a high grade educational undertaking.

It is to be concluded that there will always be the problem of making the best operator possible out of both laymen and the technically trained man. The operators' short school is just another means of improving his ability and usefulness. In conclusion, I would say it is not the need or the value of an operators' short school that calls for debate or proof here, so much as the practical problems of planning and conducting the schools.

DISCUSSION

L. B. Reynolds: "I desire to call your attention to a mass of data which I have accumulated on schools in other areas and invite anyone interested to look it over at his convenience."

T. R. Haseltine: "The University of Southern California has in addition to its other activities, established a school of Citizenship and Public Administration, and Mr. Sykes, assistant to the Dean of this school, is present today and has kindly consented to tell us something of it and how an operators' school might be conducted in connection with that course. While it is a different type from that which we

contemplate, I think he may have some pertinent remarks to make."

Walter Sykes: "Mr. Chairman and Gentlemen: One or two remarks about why I happen to be here. First, let me say I am not an authority on sanitary engineering or sludge disposal, and please do not think that the University of Southern California or the Los Angeles Chamber of Commerce delegated me to attend this meeting. One or two of the members of your own Association who have been actively connected with this Association for years, suggested that while I was in this area I might be able to attend. I jotted down some points about the annual Institute which I thought might be of interest to you.

"The first session of the school was held in 1928—as a matter of fact, it was not our own idea but that of a group of public officials—so it is largely a public office program and started from that. Since 1928 it has been held every year with the exception of one year. The next session of the Citizenship School will meet from June 10 to 14 of this year. As an indication of how the program will be worked out, a series of lectures and round-table discussions will be held. For two years we have had Abel Wolman and such men as Waring from the State of Ohio, and Ernest Boyce from the State of Kansas, who led last year.

"Half the time was devoted to water purification and half the time to sanitation. This year we are combining water and sanitation. The School differs somewhat from the one in New York, which was held 3, 4, 5 of April. Then along in May they will have a meeting of the Park and Recreation officials. We combine all these at the same time. The sections divide into their respective groups and are attended five days of the week. One hour during each day we have someone give general lectures on Government. Last year Dean Hatton from Northwestern University, Chicago, Illinois, lectured. A series of lectures will be given by the man who is leading this year—Abel Wolman of Maryland.

"Many authorities in California will read papers of a duration of from ten to fifteen minutes and a general round-table discussion of intensive interest will be led by officials. These consist of men interested in that particular phase of work—the Chairman, Ray Goudey, Mr. Rawn, Mr. Morris and Mr. Arnold.

"So far as the fees of the Institue are concerned, they have varied all the way from $5.00 to $15.00 per individual. This year the fee is $10.00. All men whose salaries are $200.00 or less will be charged a fee of $5.00.

"This year a Public Health Section will be included in the School, so arranged as not to conflict with either the Public Engineering section or the Sanitary Engineering and Water Supply section. The Public Engineering section is designed particularly for those who desire information regarding governmental mapping, surveying, earthquake hazards and the like. The Public Health section is designed particularly for attendance by Public Health employees, but it has

been arranged so that the Public Health and Public Engineering sections will not conflict with Water Supply and Sanitation.

"A certificate is given to each individual who attends seventy per cent of the lectures and classes held, strict record being kept of attendance. It is our belief that the Seventh Annual Session program, which is the one next June, as worked out by committees interested, will be one of the most successful sessions of the Institute.

"The total fees paid by those in attendance at the Institute of Government, or as your president has termed it—the School of Citizenship and Public Administration—in any one year, have not quite defrayed fifty per cent of the total cost of the Institute—the remainder being contributed by the University."

H. F. Gray: "The matter of training operators has been talked about and discussed at length for a number of years. There are certain questions that I think ought to be very well thought out. First, the matter of desirability and necessity of the school itself. Also, what is the idea of the school going to be? What sort of men are you going to turn out—that has not been satisfactorily discussed. I am going to raise the question and maybe some of the fellows can answer. My desire is that we have an operators' school, but what demand is there for it? How many would think well enough of the idea to take the course? Unless you have a fair number of people you want trained, there is no particular use in going into the work connected with a School for Operators. It seems to me that if that is going to be considered we ought to be careful to determine in advance how many men there are who would be apt to take that particular work. There is the matter of the length of time of the course in each particular year. At the present time it is rather doubtful if a considerable number of men could take time from their work to attend for ten days or two weeks. I suggest that instead of bringing the men to the school, bring the school to the men, on wheels; give the training in the man's own plant—on wheels. I think that is a practical scheme if funds are available. It would cost more to do that, but I think it would be far better than if you bring him for three days into any university."

Bard Livingstone: "If you take a man and put him in a laboratory, then send him back to operating a plant where there is no equipment on the order of that with which he has been trained in the technical school, as a suggestion I would say that it would be far better to send a man to the school to teach him how to operate under conditions which exist in his own plant."

H. F. Gray: "I would like to hear what some of these operators have to say."

A. B. Shearer: "I am a newcomer in this work—six months—although I have been in the plumbing business a good many years. I heard the remarks made about the school—if there is a school I should certainly be there. I hope you can find a way to operate it."

T. R. Haseltine: "My idea of a school is that it should be more than a school of chemistry and bacteriology. For example, you can go

around through plants any place and see meters up on the wall that are supposed to be registering and are not. We could have a school where a man could bring his meter and tear it down and put it back together again; also pumps, chlorinators, etc. I believe it would be a big help."

A. C. Beyer: "My suggestion is that it might be well for a committee to send out questionnaires to operators throughout the State and get their reaction and see if they are interested and in what type of work.

"I wish to thank Professor Reynolds for bringing up the subject of licensing of operators in connection with his discussion of a school, since experience in other States has indicated that supplementary instruction and training of operators is essential for their proper operation of any operators' licensing laws—or any set of regulations for the qualification of operators. Incidentally, insofar as the work of our committee is concerned, I prefer to consider the subject as one of the qualification of operators rather than of licensing."

T. R. Haseltine: "The original idea of having this school at all originated by having a committee work on the school for licensing of operators and the qualifications of operators."

A. W. Wyman: "Maybe some of these consulting engineers would like to go into competition with us. I thought Mr. Currie might have an idea about the State Board of Health on wheels."

F. S. Currie: "I talked over all this with Mr. Gillespie and two or three others. It seems to me a very good service could be offered these operators if a portable laboratory could be operated at a nominal fee, visiting the different cities—depending upon the size of the plnt. They could call upon some plants two or three times a month and that service would be maintained by the cities involved."

G. T. Luippold: "In Southern California there are several firms that are in the business of servicing swimming pools and they charge anywhere from $15.00 to $20.00 per month for the service. These men go around and actually check the results of the operators. Country clubs, etc., pay a fee of $15.00 to $20.00 for this inspection service."

Robert Linton: "The obvious difficulty in connection with such schools as are now being held is to crowd into three or four days a line of instruction, whether it be laboratory or questionnaire, enough which will be of real benefit. In order to make it beneficial it will have to be very carefully planned and avoid being very general in its connection, so that the man won't go away having heard what he already had heard before. The presentation of the school will be more or less along the line of post-graduate rather than elementary work. Along with a plan of three or four days' session might be included a certain amount of 'grade school work.' From time to time those who enroll with the school might have specific problems to work out and along with these there might be required a certain course of procedure. All these would lead up to a more intensive work to be done and in that way the knowledge and training increased. Then

those who would be enrolled in the school would be able to secure some actual good out of the school."

T. R. Haseltine: "Literature should be prepared and sent out to the men who intended to attend so that they would be prepared to meet what the school would present."

E. A. Reinke: "Mr. Jacobsen, Superintendent of Construction, University of California Farm, Davis, California, and our past president, is conducting short courses somewhat on the order of what Mr. Sykes mentioned is being done at U. S. C. They have been giving, for a number of years, a short course in Dairying. They get from 25 to 50 dairymen to come up to Davis to spend some thirty-five days in both lecture and laboratory work. Just a few days ago I was in Davis and asked Mr. Jacobsen if he could not find out something about the history of these dairy courses, the demand for them, whether it came from the dairymen or the University as an experiment. I also asked him what the attitude of the Agricultural College would be toward having a group of men from this Association, say ten to thirty, attend for three or four days. What would they be able to furnish for equipment in order that we might have something down here to talk about. The budgets are very small. Mr. Jacobsen stated that he would talk with the Director and come down here, perhaps, to discuss the subject. I received a letter before I came down saying that he would not be able to attend. The letter reads as follows:

'Since it is impossible for me to attend this conference of the California Sewage Works Association, I am sending you this letter with some information concerning the problems that you and I discussed yesterday.

'I talked with Dr. Howard, the director, and Mr. Smith, the comptroller, and asked if they thought it would be possible for us to have a sewage conference here several days each year, and also if we might be permitted to carry on some research work with our sewage system here at the University Farm. Dr. Howard stated that such plans would be satisfactory with him and that the University would gladly loan the use of equipment, laboratories and any assistance that would be desired.

'Personally, I believe that if we could get in touch with Professor Hyde, Dr. Walker, Dr. Mudge, and Professor Adams we could arrange an interesting program for such a short course which would develop into very useful and valuable instruction. Our Davis and University sewage plants would gladly welcome the engineers of the Association.

'I am very sorry that I cannot attend the meeting, as I would liked to have seen the Fresno and Ledmoore plants again. I hope that you have a very successful meeting and a large attendance.

'If there is any further information I can assist you with let me know.

'Yours very truly,

'(Signed) J. JACOBSEN,

'JJ:BJ 'Superintendent of Repair and Power.'

"Letter dated April 25, 1935.

"I present this as Mr. Gray has brought out that you must have something concrete to discuss, otherwise it would be of little value. One of the principal points that was brought up at the time we organized this Association was that such an Association would serve as an educational group to encourage able operation of plants and it seems to me that this step towards an Operators' school should be considered very carefully. Then another question was—how many city engineers would send their operators, if at all."

Carl Tennant: "Before I signified my intention of going to an Operators' School, I would inquire what was to be taught. It takes time to attend these sessions and it is difficult to leave the job. Furthermore, they cost money and it would not be my intention to attend something which was of no interest or benefit to me."

E. A. Reinke: "I think Mr. Tennant's point well taken. The course would probably have to be arranged to fit the needs of those who would attend—among whom would be a very mixed educational background. The course would need to be arranged very carefully."

A. M. Rawn: "Mr. Tennant's point is well taken and his question probably prompted by a desire to find out what could be taught him in the method of operation of a plant which he cannot learn, by experience or otherwise, in the plant of which he is chief operator. There are probably few plants in California or the West generally, maintaining a staff comparable with that in Tennant's plant, where not only a routine chemist, but a research chemist and a research engineer are constantly on the job. I feel that an Operators' School is not for men who are qualified superintendents of such plants, but should be more especially prepared and conducted for those individuals whose chance of learning is quite limited and whose knowledge of operation is likewise limited because of location and environment."

F. A. Batty: "It is my belief that all operators would gladly attend, and I think we would have a splendid representation at such a school from all parts of the state."

H. O. Banks: "So far in this discussion it appears that much emphasis has been placed on purely laboratory technique. In planning the curriculum of an Operators' School, lectures in simplified terms should be provided and the operator should be instructed in such a manner as to be able to apply his knowledge promptly upon return to his plant.'

J. A. Clark: "You have been discussing largely a school for those who have already had schooling. There are many, I believe, who are totally untrained, both in any educational background and in sewage treatment, who have been placed in charge of sewage treatment plants and to whom the most simplified form of training in sewage plant operation would be of great benefit. It is my opinion that a school which is very elemental in character would attract men from such communities; provided, always, that the operator or some organization could finance his attendance."

H. F. Gray: "If we are going to get the city engineers and mayors to send sewage plant operators, we will have to exercise care in the preparation of the curriculum so that its benefit to the operators will be apparent, both to the city engineer and to the operator. If we can persuade the city engineer to sell his operator on the idea and give him an understanding that there might be a raise in it somewhere if he improves himself, it might be of benefit to an operators' school."

J. C. Albers: "Most cities in the state belong to the California League of Municipalities. This League has a monthly publication known as *Western City*. Would it be appropriate to reserve a page a month in their magazine and commence a course of training for operators without cost? I refer this question to Mr. Updegraff, editor of *Western City*, who is in attendance at this meeting.

W. R. Updegraff: "I am interested in this problem. I have been asked by League officials to attend this meeting and report to them what you desire in the way of publicity in *Western City*. The League is thinking of the desirability of sponsoring the school, but desires to await action of this group before deciding, as the budget is limited. Our magazine is limited as to space, but I can assure you that it will be possible to work out a program with *Western City* regularly giving a page to an operators' school.

W. T. Knowlton: "I suggest that the Board of Directors consider Mr. Updegraff's proposition."

W. R. Updegraff: "If you can use *Western City* to advantage, let me request that you appoint a committee to work with us. If you will give me a small committee, we will get together and go into the matter fully."

At a meeting of the Governing Board of the Association, President Haseltine was authorized to appoint a committee to make a study of the Operators' School situation. The following committee was appointed: H. F. Gray, chairman; F. A. Batty, A. P. Banta, A. B. Shearer, John Jacobsen, Joseph Wagner.

SOME NEWER APPLICATIONS OF CHLORINE IN SEWAGE TREATMENT

By A. C. BEYER*

Chlorine has basically a double line of attack in connection with sewage disposal; first as a disinfecting agent or bactericide and, second, as a very active oxidizing agent. The first mentioned role is usually thought of as the oldest, but particularly in view of the present tendency toward the chemical treatment of sewage, it is interesting to note that in its first use in sewage treatment in Great Britain about 1854, chlorine was used primarily for odor control. It was not until about 1900 that chlorine was used very much for sterilization.

The greatest development in the use of chlorine in sewage treatment has been in the last decade. During that period its use has extended to all phases of treatment and disposal. A number of the interesting advances have been made here on the Coast by members of our own association. In view of the fact that most of the developments in sewage chlorination have been during the last ten years, it seems to be appropriate that there be included in this paper a brief review of all of the uses of chlorine which have become well established.

Many Established Uses

Disinfection or bacterial reduction in sewage will probably remain the most important use of chlorine. The efficient action of chlorine is not limited to partially or fully treated sewage; in many cases the chlorination of raw sewage has given excellent bacterial reduction. I will mention later some of the more recent work done in connection with disinfection.

Goudey's work on the Orange County outfall clearly established the value of chlorination at proper points for the control of hydrogen sulphide thru the elimination of the sulphate reducing bacteria and its economy in the elimination of odors and sewer and masonry disintegration.

Later, the engineers of the Los Angeles County Sanitation District showed the value of a similar treatment in outfall sewers, at carefully selected points, in getting the sewage to the treatment plant in a fresher condition and in effect materially increasing the plant capacity.

Control of odors at treatment plants is a well-known function of chlorine. Its most efficient use is when the plant conditions are such that it can be used to eliminate bacterial action resulting in hydrogen sulphide formation. Recent work, however, has indicated that for odor control chlorine can often be more efficiently used in the produc-

*District Engineer, Wallace & Tiernan Co., San Francisco, Calif.

tion and application of ferrous chloride through the Scott-Darcy Process, which I will later discuss.

Beginning in 1926, and since, much work has been done in connection with the effect of chlorine on B.O.D. reduction. It is generally agreed that there results a 2 p.p.m. reduction in B.O.D. for every part of chlorine added, and in some cases through indirect reactions this has been larger. When chlorinating to the full demand of the sewage, a reduction of at least 25 p.p.m. or from 15 to 35 per cent, depending upon the sewage strength, may be expected.

In Baity's studies of B.O.D. reduction it was demonstrated that chlorine was effective in keeping the banks and bottoms of streams receiving plant effluents free of sewage fungus growths. His observations have been confirmed also in Illinois and at other points.

The control of flies and ponding in trickling filters by occasional heavy chlorine treatment is routine procedure at many plants.

The work of Reinke at Wasco pointed to a very effective solution of the problem of disposal of wastes from milk plants thru chlorination and disposal by crop irrigation. The New York State Department of Health has pointed out the value of final chlorination of filtered or coagulated canning waste in improving the conditions in streams receiving the effluent from such plants. A very unusual use of chlorine in the industrial wastes field is that of a 600 p.p.m. (5000 lb. per million gallons) dosage of a packing house waste to recover high nitrogen content solids. Later work has indicated a combination of chlorine and small dosages of ferric chloride is even more effective and economical.

Travaini, at Phoenix, proved the value of Goudey's recommendations that chlorine be used to thicken surplus sludge from the activated sludge process. Not only did chlorination prove of value in thickening the sludge to be placed in the digestion tanks but decanted liquor from the thickener could be satisfactorily disposed of in the effluent from the plant, where the residual chlorine therein was sufficient to give a good degree of disinfection in the effluent from the entire plant. Returning this chlorinated thickener liquor to the raw sewage proved even more beneficial in its value in partial disinfection to stay septic action in the primary clarifiers.

In the activated sludge process, a number of investigators have reported valuable uses of chlorine in aiding plant operation, such as Vietch at London, Ont., and Molitor at a New Jersey plant who returned upset plants to condition by temporarily carrying a residual into the aeration units.

Where plant operation requires the return of supernatant liquor from a digester to the raw sewage, heavy chlorination of this flow will allow this procedure to be followed without upsetting the plant operation. Better yet, the sludge if thickened with heavy chlorination before addition to digesters will so materially reduce supernatant digester liquor as to render it far less deleterious to plant operation.

I have been questioned regarding the lime-chlorine process which was used at Baltimore several years ago on the effluent for the pur-

pose of reducing B.O.D. and eliminating algal growths in the tidal basin receiving the effluent. During the operation of this process there was an appreciable over-all reduction in the cost of chemicals used. At Dayton, Ohio, it has proved highly successful in prechlorination practice and more economical than the use of chlorine alone—possibly because of the chloramines formed in the alkaline reaction which the lime produces. Little work of any consequence with this method of treatment has been done elsewhere and, I believe, thre are other methods of combind chemical treatment which are more effective.

Partial Chlorination

Various studies, such as Goudey's and Griffin's, show the value of partial chlorinating to an amount well below the chlorine demand of the sewage being treated, with very effective results in bacterial reduction and hydrogen sulphide control. Recently Rudolfs has shown that with fairly fresh sewage, under proper conditions of mixing and contact, a high degree of bacterial reduction or disinfection can be obtained with dosages as low as 40 per cent or less of the chlorine demand of the sewage. Rudolfs points out the probability of the action of various N (nitrogen)-chloro products, which undoubtedly have properties similar to chloramines and, therefore, show up especially well with increasing periods of contact up to two hours. A long contact period is readily obtainable in prechlorination practice. He emphasizes the necessity of immediate, thorough mixing of the chlorine with the sewage after application. This is a very important point and where any appreciable flow is being treated I am sure some type of flash mixing is well justified and the additional investment would be well paid for in chlorine economy.

Inasmuch as partial chlorination—that is, chlorination to a part of the chlorine demand—is of decided value, tests which will allow a control of such partial chlorination are well to keep in mind. Where it has been established that chlorination say to 40 per cent of the chlorine demand will give a proper degree of disinfection, then the proper procedure is to periodically check the chlorine demand by increasing the chlorination of the main flow or in the laboratory until the residual is obtained; then using the standard Ortho-tolidin test the chlorine demand can be readily obtained by subtraction. In chlorination for odor control or hydrogen sulphide reduction in outfall sewers or ahead of a plant, Griffin has suggested a very practical and simple test—using the methyline blue stability procedure, and setting the chlorination at that point which will give stability for the length of time desired. A common case would be to obtain stability for the length of time until the next chlorination station, diluting body of water, or treatment plan was reached.

Another type of partial chlorination can be practiced in certain cases involving odor control and hydrogen sulphide reduction. The procedure referred to is chlorinating only a part of the time such as

during peak flows, or during the warm season of the year. This is often practical and results in a high degree of economy of chlorine.

Chlorine in Chemical Treatment

Recently Enslow listed chlorine, lime and iron salts as the three most valuable chemicals in sewage treatment. The possibilities of chlorination can well be illustrated by reference to the Shades Valley Plant in Birmingham, Alabama, and to the various successful uses to which the Scott-Darcy Process has been put in the Central Southwest.

In the Shades Valley Plant the first thing one must call attention to is the extreme flexibility allowed by the design. Provision is made first for screening the sewage; there are two clarifiers which can be operated either in series or in parallel. If the clarifiers are being operated in series chlorine can be added to the raw sewage or ahead of the second stage of clarification; at the same time chlorine can also be used with ferrous sulphate to give chlorinated copperas (a mixture of ferric chloride and sulphate) and provision is made for adding this chemical along with flash mixing and flocculation either ahead of sedimentation if the two clarifiers are operated in parallel, or ahead of either or both stages of sedimentation in the event that the clarifiers are operated in series. The method of operating the plant depends on the degree of treatment desired, which in turn depends upon seasonal requirements, the highest degree of treatment being required during low flows of the summer months when the receiving stream is used for recreational purposes.

Pre-chlorination or intermediate chlorination with single stage sedimentation gives all that is necessary in the way of bacterial reduction and odor control during the heavy stream flows of the winter months. Other combinations result in an intermediate degree of treatment.

Reports on the plant have been very favorable to the high degree of treatment secured under a plan of operation similar to that worked out by Stevenson, which involves two stage sedimentation with the application of the chlorinated copperas or iron salt ahead of the second stage and return of the secondary sludge to the raw sewage ahead of the primary clarifier. The remaining chemicals in the returned secondary sludge aid in settling the raw sewage and in eliminating odors. For the maximum degree of treatment Hendon at Birmingham has used on the average 70 lb. of chlorine and 440 lb. of ferrous sulphate (copperas) per million gallons of sewage. This amount of chlorine is not only sufficient to convert the copperas into ferric salt, but also to carry a residual in the plant effluent of approximately 0.25 p.p.m., insuring sterilization.

Scott-Darcy Process

The Scott-Darcy Process is one in which ferrous or ferric chloride is produced from chlorine and scrap iron. An efficient equipment

set-up has been worked out by the adaption of a vacuum solution feed chlorinator. A strong solution of chlorine water from the chlorinator is passed through a re-action tank or tower in which scrap iron has been placed; with the proper control over concentration and contact period this gives either a solution of ferrous chloride or a mixture of ferrous and ferric chloride, as desired. If 100 per cent ferric chloride is required this resulting solution is chlorinated either before applying to the sewage or after application.

Where concentrated solutions of ferric chloride are of advantage, such as would be the case in large installations, a method of recirculation and building up of the concentration has proven very satisfactory.

Practically any type of small scrap iron is well suited for use with this process and the usual sources are machine shop turnings or old tin cans. The scrap iron may be handled without any special care, and the rustier it is the better. Most of the installations to date have secured scrap iron without cost, other than that of hauling.

About 5 per cent of the flow to the Oklahoma City Southside Plant, or about 3 m.g.d., is a concentrated packing house waste flowing into the system through an outfall line several miles long. The total solid content of this flow is in excess of 3,000 p.p.m. and the hydrogen sulphide generated along the line resulted in a very serious odor nuisance and rapid disintegration of the sewer.

Even with large enough dosages of chlorine to eliminate hydrogen sulphide near the point of application, in this packing house waste, resembling sludge more than sewage, enough sulphate reducing bacteria were left to generate more hydrogen sulphide within a very short distance. With chlorine economically impractical in this very difficult case, Mr. L. H. Scott, in charge of water treatment and sewage disposal for Oklahoma City, and Mr. H. J. Darcy, chief engineer of the Oklahoma State Board of Health, starting with the knowledge that ferric oxide is used in removing hydrogen sulphide in gas plants, conceived the idea of adding ferric chloride to not only take care of any hydrogen sulphide existing at the point of application, but with a residual of the iron salt sufficient to combine with any subsequently formed hydrogen sulphide. This led to the development and installation of the process, using the special vacuum solution feed chlorinator and iron scrap filled reaction tank, described above.

The installation was highly successful in eliminating odors and hydrogen sulphide both at the point of application and all the way to the treatment plant. Further work indicated that ferrous chloride was an even more economical type of treatment, since when using ferrous chloride more hydrogen sulphide is removed per pound of chlorine used. For this exceptionally strong sewage only 75 to 100 lb. of chlorine per million gallons is required and since the chlorine constitutes the principal element of cost of the treatment it is evident that the results are being obtained very economically.

Oklahoma City Northside Plant

This led to other work and finally to the re-design of the second or Northside Plant at Oklahoma City to use the process in connection with two stage sedimentation. After seeing this plant in operation I was convinced that it was one of the most interesting in the country and I, therefore, feel that a brief description of the entire plant will be of interest.

The plant treats an average flow of approximately 4 m.g.d.. As the flow enters the plant, ferric chloride from a Scott-Darcy generator plus lime is added; the sewage then passes through a very economically operated comminutor, which not only macerates the large solids but also acts as a flash mixer for the ferric chloride and lime. This is followed by a mixing device in which the sewage is given approximately 20 minutes flocculation and from there it flows to two clarifiers operated in series. Final chlorination for disinfection is added ahead of the secondary clarifier.

Sludge from the secondary clarifier averaging 1 to 2 per cent solids, is returned to the raw sewage. Sludge from the primary clarifier, averaging 10 per cent solids, is continually removed, treated with lime, and in the fresh, undigested condition, is de-watered on a filter to give a sludge cake averaging about 65 per cent moisture. This sludge cake is without odor except for a slight smell of lime, and is satisfactory dumped in open piles or used for fertilizer.

Before the Northside plant was re-designed, the condition of the receiving stream, which flows through a district where there are a number of high-class country homes and clubs, was so highly objectionable that the city was faced with numerous suits. Since the plant has been remodeled to use the Scott-Darcy Process as described, former odor nuisances at the plant have been eliminated and the effluent is disposed of without nuisance in the same stream where there is little if any dilution during the dry period of the year.

Sewage reaching this plant is septic and high in hydrogen sulphide; the treatment reduces the suspended solids from 200 p.p.m. to approximately 15 p.p.m. and the B.O.D. from 185 to less than 20. A recent check indicates that these results are being secured for a total operating cost of a little over $8.00 per million gallons, one half of this being for chemicals. The total amount of chlorine used is approximately 60 to 70 lb. per million gallons, one half being for the ferric chloride generation and the other half for sterilization. The total amount of lime used both along with the ferric chloride and for sludge conditioning is from 700 to 800 lb. per million gallons.

In the general application of this process either ferrous or ferric chloride can be used; where the object is primarily odor control, then ferrous chloride is employed, the treatment in most cases being in the outfall sewer ahead of the plant. Where better solid removal is desired, as well as odor control, ferric chloride is used, or in some cases, previously added ferrous chloride may be converted to ferric farther

down the line, or at the treatment plant, by the subsequent addition of chlorine.

Chemically the advantage of the iron salts in odor control is that they have no affinity for organic matter or other reducing substances, such as thiosulphates, sulphides, etc., while in the case of chlorine, such reducing agents all require sufficient chlorine to re-act with them, thereby cutting down the efficiency of chlorine with respect to hydrogen sulphide, the main offender. As a result, the available iron re-acts principally with the hydrogen sulphide that may be present, while the remainder is available as a residual in the sewage to combine with any subsequently formed hydrogen sulphide. Any ferrous chloride added, will have the new, well established advantages at the treatment plant, particularly where aeration or subsequent chlorination is practiced; these advantages include better solid removal, improved sludge digestion or dewatering, clearer supernatant liquor, and chlorine economy.

Required Chemical Quantities

In Oklahoma, Kansas, and Arkansas, there are now over a dozen plants using the Scott-Darcy Process, including practically every type of plant. As a result of experience at these plants, it has been estimated that on the average, the following amounts of chemicals will be required:

For ferric or ferrous chloride formation—from 30 to 50 lb. of chlorine per million gallons.

For supplementary lime treatment—from 300 to 400 lb. per million gallons.

Where fresh sludge is to be filtered, about 300 lb. additional lime per million gallons is apparently required.

For final chlorination, for sterilization, following efficient sedimentation with ferric chloride—approximately 25 lb. per million gallons.

The supplementary lime treatment has been found to be of advantage when used as at the Northside Oklahoma City Plant. Likewise, it is of value in raising the pH sufficiently to precipitate out a greater percentage of the ferrous sulphide formed in the hydrogen sulphide elimination, thus eliminating any objectionable black color in a plant effluent.

It is well established that wherever ferric chloride is being used, for the most economical results it is desirable that sufficient excess chlorine be added to keep the ferric chloride from being reduced to ferrous chloride which would leave less of a ferric salt available for coagulation and precipitation of solids. In the Scott-Darcy Process this excess chlorine is simply and automatically added; as a matter of fact even where ferrous chloride is being used, any excess chlorine carried along when using the process, is undoubtedly of material value.

The success of the Scott-Darcy Process has been confirmed not only throughout the Central Southwest but at York and Lincoln, Ne-

braska and Princeton, New Jersey. Among the additional installations definitely planned is a good sized plant for El Paso, Texas.

From the foregoing it is not to be concluded that ferric or ferrous chloride treatment will altogether supplement straight chlorination for odor control. For example, where the sewage is not strong or there are relatively few sulphates present, straight chlorination can be used to eliminate odors and its application is of course simpler. It is essential, for the economical use of chlorine alone for odor control, that it be applied ahead of the point where the hydrogen sulphide begins to form in any appreciable quantities, so that its action can be to eliminate sulphate reducing bacteria rather than to combine chemically with hydrogen sulphide formed.

Large Capacity Chlorinators

In the past at large an even medium sized sewage treatment plants, it has been necessary to install a relatively large number of individual chlorinating units to secure the required capacities. I am glad to be able to call your attention to the fact that there has now been designed a high capacity vacuum type chlorinator, with proper refinements and safeguards, which can be obtained in single units having a capacity as high as 2,000 lb. of chlorine per 24 hours. This new, high capacity equipment has been received most favorably by designing engineers throughout the country.

It was recently stated that the fundamentals of sewage treatment were first, removing solids; second, adding oxygen; and third, killing bacteria, with the incidental problem of disposal of solids removed. From the foregoing it is evident that chlorine has many uses in all phases of sewage disposal. It seems certain that the present trend toward the chemical treatment of sewage, either alone or in combination with biological processes, will continue; it would appear equally certain that paralleling this trend further beneficial uses of chlorine will be developed.

DISCUSSION

R. Pomeroy: "The addition of ferrous chloride is for the purpose of removing hydrogen sulfide by precipitation as ferrous sulfide. Is there any reason why ferrous sulfate, or copperas, should not be used instead of ferrous chloride? Its action is just the same and it is cheaper."

A. C. Beyer: "From a strictly chemical standpoint I presume the general answer would be, there is no reason why it should not be. However, in many cases adding additional sulfate to a sewage might give additional material to revert to sulfide farther on down the line and thereby counteract what you were trying to accomplish by the addition of the ferrous iron—that is, the elimination of hydrogen sulfide. In addition, in adding ferrous chloride in the Scott-Darcey Process there is also some excess chlorine along with it, which I am confident

is always of advantage. Enslow concurs in this and points out that in general, whenever you can add chlorine to sewage there is always going to be some advantage."

R. Pomeroy: "If the cost were approximately the same the chloride might be preferred, but a ferrous salt can be made just as easily with sulfuric acid as with chlorine. Ninety-eight parts of sulfuric acid will do the same work as 71 parts of chlorine, and the acid is much cheaper."

A. P. Banta: "Perhaps the addition of ferric chloride to sewage might be an advantage under certain conditions that it would destroy hydrogen sulfide and also raise the oxidation potential of the sewage so that sulfate decomposition would not proceed. The effect in the latter respect would be similar to the addition of nitrate, and is accomplished without the satisfaction of the chlorine demand of the organic matter as would be the case if chlorine were used."

A. C. Beyer: "That is correct."

T. R. Haseltine: "I would like to ask about the control of the Scott-Darcy process. What does an operator have to do to control it? What kind of tests would he be called upon to make each day?"

A. C. Beyer: "When the process is used without recirculation to generate ferric chloride, then in the initial stage the plant is laid out so that there is plenty of contact time between the chlorine and the iron and ferrous chloride results; then an excess of chlorine is added to convert this over to ferric chloride. Where there is a recirculation setup then all an operator has to do is to keep the pump going; in this setup there is a certain amount of manipulation and setting of valves, but this is only used in the larger plants and, therefore, under a competent operator and he would have no difficulty."

T. R. Haseltine: "What kind of test would the operator be called upon to make any day?"

A. C. Beyer: "I don't think he would be called upon to make any test, as long as there is sufficient iron in the content. He governs his dose of chloride by the amount of chlorine; in a small plant he is guided by results rather than tests. The operator governs the dose of chloride either in the case of ferrous or ferric by regulating the amount of chlorine fed through the chlorinator, which is, of course, simple enough; in the small plant the operator is guided by results rather than by any tests. An operator can test for ferrous and ferric iron content, but in my opinion he would be rarely called upon to use this test."

G. T. Luippold: "In connection with what Mr. Beyer has just said, I wrote a letter to Enslow concerning recommendations he might make in connection with reduction of hydrogen sulfide by means of mechanical and diffused air methods prior to chlorination. I will read you one paragraph of his letter:

> 'I do recall a discussion with you and others which involved the matter of mechanical and diffused air schemes for a quick aeration of sewage prior to chlorine addition—primarily, for the

purpose of reducing the chlorine demand; secondarily, to affect as nearly 100 per cent spontaneous distribution of chlorine or chlorine solution as possible—and sought—greatest saprophytic organism reduction with the least chlorine possible. Also the idea was to freshen the sewage somewhat and maintain an aerobic effect as long thereafter as practicable. Now I might add if chlorinated iron (ferrous chloride) be added at remote points up the sewer to control odors and safeguard sewers ahead of the point of chlorination to effect beach protection, subdue septic action and separate emulsified greases; then the aeration will partially revivify the spent iron (ferrous sulfide) and render chlorine more effective in its further revivification. To accomplish the desired effect and to create the most flexible and least expensive installation, my thought is that blowing the air in a conduit built parallel to the existing trunk sewer will be the preferred scheme. It will also cause less breaking up of solids.'

T. R. Haseltine: "Professor Hyde made a trip East and as I recall on his way back he visited some Oklahoma plants. He told me that they had had a great deal of trouble with corrosion. I wondered if there was any reason why ferric chloride made by the Scott-Darcy process should be more corrosive."

A. C. Beyer: "There has been no corrosion in connection with the process except in one instance in connection with the recirculation setup; they tried out a pump made of Hasteloy, but it did not stand up under hot ferric chloride, which is, of course, a very corrosive substance, much more so than cold ferric chloride."

T. R. Haseltine: "What temperatures do their solutions reach in Oklahoma?"

A. C. Beyer: "It depends upon what concentration you build up. As I recall it, when they got up to 12 per cent and 13 per cent they were getting up to 175° or 190°, which is pretty warm."

CHEMICALS FOR SEWAGE TREATMENT

By J. F. SMITH*

The only chemical products used to any extent in sewerage which are manufactured by our company are liquid chlorine and ferric chloride, so I shall confine my brief discussion to these.

As you all doubtless know, the basis of the manufacture of chlorine is salt and electric power. Our salt is obtained by solar evaporation of water of San Francisco Bay and before going to the electrolytic cells must undergo considerable purification. First soda-ash is added to precipitate calcium and then magnesium is removed by the addition of caustic soda. As a matter of pratice, the salt dropped out in the vacuum pans in which caustic soda is concentrated is added and this contains enough free caustic to precipitate the magnesium. The brine is then made slightly acid with hydrochloric acid and goes to the cells as a saturated solution containing about 25 per cent salt, or 300 grams per liter.

There are a number of types of cells in commercial use, but the one we use is the Allen-Moore. It consists of a concrete body with iron cathodes and graphite anodes, there being a paper diaphragm between the two electrodes. The flow of brine is from the anode to the cathode and the diaphragm retards the flow so that there is always a slight head on the inside which prevents any caustic soda diffusing back and coming in contact with the anodes. These cells are arranged in banks, there being 64 series in each circuit. The electric power is received at our plant at 22,000 volts A. C. and, after being stepped down by transformers to 190 volts A. C., it goes to the rotary convertors, of which there is one for each circuit. The power goes to the circuits at approximately250 volts D. C., there being 3½ to 4 volts on each cell. The load is set monthly in accordance with the amount of chlorine which the sales department is optimistic enough to think can be sold. The load varies from 900 to 1600 amperes. Our normal production is about thirty tons of chlorine a day, the plant capacity being about 38 tons.

In the electrolytic decomposition of salt solution, as you may know, the chloride ions travel to the anode and there give up an electron and are discharged as an atom of chlorine. The sodium ions travel to the cathode, there receiving an electron and becoming sodium atoms, which immediately react with the water to form caustic soda with evolution of hydrogen. The decomposition of the brine is not carried to completion and the liquor flowing from the cell contains about 9 per cent sodium hydroxide and about 17 per cent salt.

The cell gas coming off the anodes contains about 99 per cent plus chlorine and is pulled by Nash pumps through earthenware pipes, being cooled and then dried with sulphuric acid. By compressing to 100 pounds pressure and cooling to -21 degrees C. the chlorine is liqui-

*Sales Manager, Great Western Electro-Chemical Co., San Francisco, Calif.

fied and is then filled into tank cars and cylinders, the liquid being more than 99.9 per cent pure.

The caustic liquor is evaporated in triple effect vacuum pans and most of the salt drops out. This salt, as explained before, contains a certain amount of caustic and is added at one stage of purification of the brine to precipitate magnesium. The caustic soda solution is concentrated to about 50 per cent and is either sold as such in tank cars or further evaporated in directly fired pots to make solid or flake caustic soda. The caustic soda produced is in the ratio of 53:47 as compared to chlorine.

The hydrogen coming off the cathodes is collected and mixed with air in the proper proportion so that when burned the oxygen is all removed and there remains three parts of hydrogen and one part of nitrogen in the resulting mixture. This gas is compressed to 3500 pounds, to 5000 pounds, and heated to 550 degrees C. It is then passed through a catalyst and reacts to form ammonia. Our production of ammonia amounts to about 2½ to 3 tons per day, a part of this being used in water purification.

In the manufacture of ferric chloride, the raw materials are scrap iron, ferric chloride solution and chlorine. Preferably very fine scrap is used, such as baling wire, and this is charged into the reaction chamber together with a certain amount of ferric chloride solution. Then steam and gaseous chlorine are introduced until a certain point is reached. Naturally, in the presence of metallic iron a considerable amount of ferrous chloride is produced, so it is customary to withdraw the solution and finish the chlorination out of presence of iron until all ferrous iron has been completely oxidized to the ferric condition. Obviously, the purity of the ferric chloride will depend largely upon the purity of the scrap iron used and, naturally, scrap iron is not a dependable material as regards purity. In order to obtain a satisfactory product, therefore, it is necessary to put it through processes of purification and long settling. The ferric chloride is then either shipped in rubber lined equipment as a solution containing 43-50 per cent $FeCl_3$ or it is concentrated to about 58 per cent, at which point is solidifies and it is then packed in steel drums. Strangely enough, if the concentration is brought up as high as 65-66 $FeCl_3$, the material is not a solid but a liquid and an effort was made to market the material in this condition in wooden barrels. The condition is not very stable, however, and the material is likely to solidify in transit.

So much for the manufacture. When we come to the rest of the question, which is cost, I find myself, however, facing a much more difficult problem. At the risk of giving away trade secrets, I must confess that, of the factors which influence price, the most potent is competition,—competition between manufacturers of the same commodity and competition between commodities serving the same purpose. I do not mean by this that where no competition exists the manufacturer will attempt to get all the traffic will bear and that it is only our competitors who prevent us from robbing the consuming public. Theoretically, selling price should be cost of production, plus

cost of distribution, plus a reasonable profit. However, cost of production in many cases is largely a matter of bookkeeping and cost of distribution from one point may differ greatly from that from another point. Obviously the success of any manufacturing enterprise depends upon maintaining a certain volume of production and, in order to do so, it is often necessary to compete in territories where the net return is less than the average cost of production. It is necessary, therefore, in some other territory to charge a price which would seem to yield a little more than a fair margin of profit and to do so is not necessarily to take unfair advantage of the customers. As a matter of fact, competition and lower prices are sometimes a blessing in disguise, as they lead to economies of production which might otherwise be overlooked.

The factors entering into the cost of making chlorine are power, salt, labor, overhead and depreciation, and naturally these all vary somewhat with volume of production. It is apparent that if we can run our plant at a uniform production of 35 tons per day our cost will be much less than if we run 35 tons per day one month and only 20 tons the next. The actual cost must be, therefore, an average of the good months and the bad. To this cost must be added interest and depreciation on the very considerable investment in tank cars and cylinders, upkeep and replacement of valves, etc., freight (including return freight on empty cylinders) and sales expense, including commissions paid to distributors, etc. The item of freight is a very considerable one, for, in order to ship 100 pounds of chlorine in a 100-pound cylinder it is necessary to pay freight on 200 pounds going and 100 pounds returning, so that on long hauls the freight often amounts to more than the value of the material.

In the manufacture of ferric chloride the factors are cost of chlorine, scrap iron and steam, plus labor, overhead and depreciation, freight and investment in rubber-lined tank cars, etc. Naturally the cost of chlorine is whatever figure you wish to put in and the price at which you can afford to put in the chlorine depends largely upon one's ability to sell the material elsewhere at a profit. If a company can sell its entire output of chlorine at a fair profit, then, obviously, to charge chlorine into ferric chloride at a figure lower than the selling price is to lose money. On the other hand, if putting chlorine into ferric chloride means furnishing much needed volume of chlorine production then we can afford to charge it in at a very low figure. When you consider that ferric chloride solution is 50 to 60 per cent water and solid ferric chloride is 42 per cent water it will be seen that the item of freight is a very important one.

No doubt what you are most interested in knowing is what price you will be compelled to pay for chemicals in sewage disposal in the future, and I must say frankly that I don't know. So far, we have been able to revise our prices downward rather than upward in spite of increased labor costs due to the operation of the NRA, etc. There must be, however, a limit to the possibility of cutting costs and there is, of course, a chance that inflation or some other cause may force

prices upward.

It is my personal opinion that prices on liquid chlorine and ferric chloride in California in the near future will probably be lower, rather than higher. We have at the present time a project under way for manufacturing operations in Los Angeles which should help to bring this about.

Mr. Beyer, in his paper yesterday, called attention to the fact that the cost of chlorine at a particular Eastern plant was considerably lower than prevailing prices in California. Without wishing to appear on the defensive, I think that this would stand some explanation. In the first place, it may interest you to know that the fact that chlorine prices in California are at the present as low as they are is due almost entirely to the presence of the pulp and paper industry in the Pacific Northwest. Up to 1928 it was not possible to manufacture chlorine in California at a cost which would compare with the present selling prices. About that time the pulp mills in the Northwest began to use liqid chlorine in large quantities and new mills were built, this giving the needed volume to enable us to reduce the cost of operation very materially. Unfortunately for us this new development also brought new competitors into the field and two competing plants were erected in Tacoma. The fact that freight rates to the pulp mills from Pittsburg are on an average about $10.00 per ton higher than those applying from Tacoma naturally militates against the possibility of lower prices on chlorine for California. You can readily appreciate that if two-thirds of our production is shipped into a low priced market with high freight rates, if our average return is to be a fair one the prices in other markets must be correspondingly higher. It will probably interest you to know that one good sized pulp mill in the Northwest will use as much chlorine in a day as is used in the entire field of sanitation in the State of California.

DISCUSSION

J. F. Smith: "In discussing the amount of chlorine used, probably one good Northwest Pulp Co. will use more chlorine in one day than all of the sanitary plants on the Pacific Coast will use in one month."

R. Pomeroy: "Yesterday I asked Mr. Beyer regarding the relative merits of ferrous sulfate and ferrous chloride. Along the same line I should like to ask if Mr. Smith could tell us something of the relative cost and efficiency of ferric chloride and ferric chloro-sulfate (chlorinated copperas—a mixture of ferric chloride and ferric sulfate). I understand that this mixture is being used at the present time at a number of plants in the East and that iron is considered to be nearly, if not equally, as effective in that form as in the form of ferric chloride. The chlorinated copperas can be easily made by treating an excess of iron with sulfuric acid and chlorinating the solution. Taking the cost of scrap iron at $6.25 a ton, sulfuric acid 66° $17.00 a ton, and chlorine $65.00 a ton, the cost of chemicals to make a ton of chlorinated copperas is $23.50, or to make enough of the compound to

be equivalent to a ton of ferric chloride is $27.20. Ferric chloride costs about twice that much."

J. F. Smith: "Mr. Stevenson can answer Mr. Pomeroy's question better than I can. However, what he says about the relative merits of ferric chloride and chlorinated copperas is true. As a coagulant it makes little difference which form of iron is used. Which compound can be made more cheaply depends upon the circumstances. A company making chlorine can produce ferric chloride more cheaply, because it can use chlorine which would otherwise be wasted. Also, the chlorinated copperas cannot be concentrated as highly as the chloride, so that it would be necessary to pay freight on 60 per cent more weight. Possibly Mr. Stevenson can give you more information."

R. A. Stevenson: "I find it rather difficult to discuss the paper, since I am in agreement with everything which Mr. Smith says. His paper covered everything very completely, but one thing he did not touch on was the use of lime in purification. While that has not received a great deal of attention on the Pacific Coast as yet, however, it will in the future. We have found in working in the United States Lime Products Corp. that it is possible to take a given limestone and by different methods of burning to create two entirely different limes. The lime is burned in a rotary kiln at a certain temperature and the quicklime is then hydrated. Then a settling rate is taken. Some limes require 33 minutes to settle to a given point, while other limes require 2 hours and 33 minutes to settle to the same point. While the importance of that in sewage is not very clear, however, I imagine research will be undertaken along these lines in the future. What is required is to keep the lime in suspension long enough to react.

"As to the use of chlorinated copperas, it is cheaper on a manufacturing scale to chlorinate iron than to use sulfuric acid, but chlorination of copperas may be desirable in some situations."

A. C. Beyer: "I would like to add to Mr. Pomeroy's statement. On the East coast ferrous sulfate or copperas is much cheaper than on the Pacific coast, and, therefore, chlorinated copperas is a relatively cheap ferric coagulant. Whether or not they use ferric chloride, ferric sulfate, chlorinated copperas or some other ferric salt, depends primarily upon the cost of the respective chemicals, taking into account the convenience in handling and application. With reference to the subject of manufacturing a ferric coagulant from raw materials, particularly in the small plant, there is, of course, some possibility that the manufacturing plant setup would be unduly complicated and it might be of advantage to purchase a manufactured product. In any event, not only the cost of the chemical, but the cost of applying that chemical should be taken into account."

T. R. Haseltine: "Professor Hyde's paper, given last Fall at the meeting of the Water Works Association, is now being printed and published in the *Journal* of the American Water Works Association. He and Professor Langelier have made a careful study of ferric chloride and chlorinated copperas and they consider them about equal as co-

agulants. I think if that paper is read it will give an explanation of a lot of this discussion in a very clear manner."

A. C. Beyer: "I would like to point out that using chlorine in tank car lots is not an impossible thing to expect even for a medium-sized plant; at the Southside Plant at Oklahoma City, treating in the neighborhood of from 12 to 14 m.g.d. per day are using at the present time chlorine in tank cars."

H. F. Gray: "What differences in the burning of the lime are chiefly responsible for the differences in quality?"

K. Ellsworth: "The duration of the burning makes some difference, but most of the difference is due to the temperature of the burning."

R. Pomeroy: "I think that Mr. Stevenson is correct in his statement that the use of lime in sewage treatment is due to receive more attention. On the basis of some laboratory experiments at the plant of the Los Angeles County Sanitation Districts it appeared that for high dosages lime was just about as economical as were ferric salts in the coagulation of sewage. The good showing of lime in this case may be partly due to the fact that the sewage used in the experiments contains quite a bit of iron which enters the sewer from steel mills. In any case the use of lime is worth further study. We also made some tests to determine what would be the most economical combinations if lime and ferric salts are used together. The experiments indicated that no combinations are more economical than one or the other chemical alone."

K. Ellsworth: "In the past, limes have been generally rated on the basis of their calcium oxide content. The present trend is toward investigation of settling rates and other characteristics of the lime. You may find that one lime is 15 per cent to 20 per cent less efficient in water purification than another lime of the same calcium oxide equivalent."

J. F. Smith: "I am not familiar with lime and water treatments, but there is certainly a great deal of difference in lime. For a long time we used lime made from a limestone deposit in Tuolumne County. Then we changed to oyster-shell lime and found quite a difference—it was more fluffy. We had to change the size of the drums to get the same amount, as it took more to weigh the same."

K. Ellsworth: "I have some pamphlets on water supply and treatment. I think you will find them very interesting. We will furnish copies to anyone who desires them."

T. R. Haseltine: "Have the physical characteristics more to do with the efficiency of the lime than has the rate of settling? If two types of lime have different settling rates, does the rapid-settling always have better qualities as a coagulant?"

R. A. Stevenson: "We have in several instances duplicated the slow-settling lime with the fast-settling lime and have found that the slow-settling lime is much more satisfactory than the other."

PROBABLE FIELD OF CHEMICAL TREATMENT OF SEWAGE IN CALIFORNIA

By R. F. GOUDEY*

There are three factors bringing chemical treatment of sewage to the forefront. One engineer has referred to this movement as the "renaissance period of chemical treatments". Manufacturers of chemicals from coast to coast have been seeking new markets for their products and for chemical feed equipment. Four out of five articles on chemical treatment of sewage appearing in the Sewage Works Journal during the past year have been written by manufacturers. A number of engineers are openly resorting to chemical treatment in order to circumvent activated sludge patents. These two tendencies are very important factors in arousing renewed interest in chemical treatment.

All manufacturers of chemicals in general and the engineers prejudiced against activated sludge are united in condemning the activated sludge without proper cause or investigation as to efficiency of the process and invariably hide the limits of their own pet processes so that the cost figures as released are not comparable with what might be done in other localities.

The third trend toward chemical treatment of sewage, born of a more constructive attitude, is being urged by the sanitary engineers of the newer schools of sanitary engineering. They see a combination of both chemical and biological processes so that better treatment can be effected at lower cost than can be obtained by either method separately. They hold that real advancement lies in polishing up, cutting corners and combining processes already developed.

The proof of the statement that manufacturers are taking the lead in exploiting chemical methods of sewage treatment is indicated in a number of references from the Sewage Works Journal for the past year. All of the articles to be quoted openly confess that their interest in chemical treatment was that of finding new outlets for their materials. For instance, in the May issue of the Sewage Works Journal (Vol. 6, No. 3, page 450) is a paper on "Results of Six Months' Operation of Chemical Sewage Purification Plant—Chicago Sanitary District" by George H. Gleason and Alfred C. Loonam, representatives of the Guggenheim Brothers Co. In order to protect the neutrality of the Sanitary District of Chicago the author inserted this note: "This paper and estimates have been prepared by the staff of the Guggenheim Brothers Co. and not as a joint report of the Guggenheim Brothers Co. and the Sanitary District of Chicago". These same authors in a previous description of their work as described in the January, 1933, issue of the Sewage Works Journal titled "The Development of a Chemical Process for Treatment of Sewage" stated, "The entrance of the Guggenheim Brothers Co. into the field of sewage

* Sanitary Engineer, Bureau of Water Works and Supply, Los Angeles.

treatment came about somewhat indirectly. For several years the firm has been interested in the production and sale of nitrate of soda and they were on the lookout for new uses of this product". They frankly admitted their inability to use nitrate of soda in sewage treatment but that they did succeed in working out a chemical precipitation with the recovery of iron in sludge after incineration and the removal of ammonia in the final effluent by the use of zeolites. It is interesting to note that Langdon Pearse in discussing the paper above mentioned stated, "The authors failed to note that from time to time nitrate of soda was used varying from 45-141 lb. per m.g., the cost of which was not reflected in the final operation expense of their process".

In the January, 1933, issue of the Sewage Works Journal is an article "Chemical Sewage Purification at Palo Alto" by Ralph Stevenson, Research Engineer, Great Western Electro Chemical Co., in which he stated, "The Great Western Electro Chemical Co. is not interested in designing or building sewage purification plants. The work that we are doing is entirely for the purpose of finding more effective and economical methods or materials for sewage treatment as outlets for our products". The author concluded that his process was more economical than the activated sludge process but did not produce figures to substantiate such a conclusion.

In the September, 1934, issue of the Sewage Works Journal (Vol. 6, No. 5) is an article by J. H. Brendlen of the Calco Chemical Co. on "The Present Status of Chemicals in Sewage Treatment". The whole tenor of this paper was the advocacy of the use of chemicals in sewage treatment and condemnation, without foundation, of the activated sludge process. A discussion of this paper was given by L. L. Hedgepeth of the Pennsylvania Salt Co.

In connection with the Dearborn, Michigan, plant, the Phelps-Dodge Corp. in their financial report for 1934 had this to say of their entrance into the field of chemical treatment, "A comparatively recent development is the Nichols Herreshoff incinerator, an adaptation of the roasting furnace to the incineration of sewage sludge. A significant achievement of the past year was the securing of a contract with the City of Dearborn, Michigan, for the incineration of sewage sludge in a Nichols Herreshoff incinerator, opening up an entirely new field in the exploitation of this furnace. As far as can be ascertained, this marked the first regular commercial installation of equipment for the successful incineration of sewage sludge".

The purpose of these remarks is not to criticize the propaganda of the representatives of chemical companies, because their research is of particular value and it is apparent that the expense involved in sewage research largely falls on their support. It is necessary, however, to critically analyze every report published by them to determine exactly what constitute limitations of their processes, what the unit costs are which would be applicable elsewhere and which are unproved dogmatic statements used to compare their processes with others. The type of answer which Langdon Pearse gave to the Gug-

genheim Brothers at Chicago is a good example of the questioning mind toward processes which have been developed specifically for the purpose of extending markets for manufacturers. On the other hand, little good can be said for those engineers who blindly turn to any of the new chemical processes just to circumvent biological processes. All efficient chemical methods of sewage treatment have been patented. In no case is it known what royalties are guaranteed. Who can say that someone will not corral the more important of the chemical patents in a few years' time and again harass the sanitary engineer? The activated sludge patents are now being settled or litigated on a basis well within reason. There is less patent troubles ahead for the activated process than for all other efficient methods of sewage treatment.

At the close of this paper an attempt will be made to show that chemical treatment can be fitted in with the physical and biological methods of treatment so that a method using all three processes is fundamentally better than any one method. It is well to maintain a neutral attitude regarding all controversial matters and get back to some clear thinking on the entire subject of sewage treatment.

Types and Examples of Chemical Treatment

Chemical treatment is a broad term now covering at least five separate functions. At first chemicals were added to increase removal of suspended solids in plain sedimentation plants. This method is still used on overloaded clarifiers and during short periods when additional removal of solids is required such as disposal of settled sewage into streams during low stages in the summer.

More recently a second method has been developed. It has been found more efficient to coagulate and settle sewage which has been previously settled and rely upon the chemical treatment to remove solids which are not readily removed by plain sedimentation. The second sludge may or may not be added to the raw sewage to accelerate sedimentation in the first clarifier. Coincident with this evolution has been the development of the use of other coagulants such as ferric chloride and ferric sulphate supplied by manufacturers or made at the sewage treatment plant. For instance, ferric chloride can be made by Wallace and Tiernan equipment from scrap iron and chlorine and ferric sulphate can be made by chlorinating copperas. Chlorine is usually added for disinfection purposes and combined with coagulants it serves two purposes.

The third application of chemicals to sewage treatment is sludge conditioning prior to rapid sand drying, dewatering with vacuum equipment and incineration. Ferric compounds with lime are used almost exclusively.

The fourth type of chemical use is the addition of chemicals as an adjunct to biological methods of sewage treatment. This involves use of chlorine, lime and ferric compounds.

The fifth method is the development of so-called complete methods of chemical treatment.

1. Coagulation of Raw Sewage.

Lime is probably the oldest coagulant used in sewage treatment. Like other coagulants, it reacts with bicarbonates present in the sewage and forms insoluble calcium carbonate, together with magnesium and iron hydroxides. The calcium carbonate floe is fine, builds up slowly and settles with difficulty. If magnesium is present the floc is heavy, large and settles rapidly. With lime treatment the pH is usually raised to 9.0 or more, which corresponds with that required in a lime softening plant using the excess lime method in which 50-60 p.p.m. excess causticity is maintained.

A good example of lime used as a coagulant is the plant at Winston-Salem. In this case lime is added to the raw sewage which, after passing through electrolyzers which gives ideal mixing, the sewage is settled and is then discharged directly into a small muddy stream. Sludge is treated with additional lime and is dewatered with vacuum equipment. The pH is raise to 9.0. The lime dosage (CaO - 90%) is 1500 lb. per m.g. and an additional 215 lb. per m.g. for sludge conditioning. The plant secures 85-90 per cent removal of suspended solids. The cost of the lime treatment for clarification alone is $7.50 per m.g., which corresponds with present unit prices here to $9.00 per m.g.

The use of iron salts for coagulation of raw sewage started when copperas (ferrous sulphate) was found to reduce the lime dosage when steel plant pickling wastes containing copperas were discharged into sewers tributary to treatment plants using lime. The process was turned around by using lime first and then adding ferrous sulphate. Plants at St. Louis, Worcester and Providence so treated their sewage. An average dosage has been 1000 lb. of lime and 75 lb. of ferrous sulphate, which gives a cost so far as unit prices here are concerned of $7.00 per million gallons. The per cent removal of suspended solids based on this dosage is about 80 per cent and is not quite comparable with the removals at the Winston-Salem plant. Apparently, however, lime dosage can be cut by substituting ferrous sulphate for part of the lime dosage and lower over-all costs can be obtained.

The use of ferric chloride as a coagulant for raw sewage has been suggested but the cost is high. The required dose usually varies between 425 to 570 lb. per m.g., which in California would cost $12.00 to $16.00 per m.g. There is no plant using ferric chloride to coagulate raw sewage.

2. Coagulation of Settled Sewage.

Plain logic dictates that if chemicals are to be used in removal of suspended solids that sewage should first be pre-settled to economize on the amounts of chemicals required. This idea has been thoroughly

covered by patents, as has the idea of using chlorine supposedly to regenerate precipitated coagulants. Two outstanding examples of this development are the experimental work at Palo Alto and the new plant at Shades Valley, Birmingham, Alabama.

At Palo Alto ferric chloride and chlorine were added to settled sewage with recirculation of sludge to the raw sewage and addition of new chemicals to the settled sewage. By using 142.5 lb. of ferric chloride and 80 lb. of chlorine per m.g. a removal of 85 per cent of suspended solids and 75 per cent reduction of B.O.D. was obtained. Based on present prices this chemical cost is $6.60 per m.g., which is less than half of treating raw sewage with ferric chloride alone. It was reported that indications were that 95 per cent removals of suspended solids and B.O.D. might be obtained with a dose of 200 lb. of ferric chloride and 250 lb. of chlorine per m.g. Current prices would make such a process cost $11.25 per m.g. solely for cost of chemicals.

The best example of the use of ferrous sulphate and chlorine for the coagulation of settled sewage is given in the March, 1935, issue of Water Works and Sewerage (Vol. 8, No. 2, page 69) in an article on the Shades Valley Precipitation Plant at Birmingham, Alabama, by H. H. Hendon. This plant had been operating on a weak sewage (suspended solids of 100 p.p.m. and B.O.D. of 80 p.p.m.) for a sixty-day period using 70 lb. of chlorine per m.g. and 440 lb. of ferrous sulphate per m.g. The raw sewage had a low alkalinity of 130 p.p.m. and contained 2 p.p.m. of iron before treatment. Some experiments were reported on strong sewage (suspended solids of 310 p.p.m. and B.O.D. of 300 p.p.m.) using 66 lb. of chlorine per m.g. and 518 lb. of ferrous sulphate per m.g. The conclusion was reached that the operating cost, including fixed charges, would be $23.65 per m.g. However, this assumed only six months' operation for chemicals and for twice the quantity of sewage that was actually treated. The chemical cost was $5.28 per m.g. and power cost was $5.48 per m.g. Unit costs were relatively low because of ferrous sulphate costing but $17.50 a ton. The unit power cost was $0.025 per K.W. hour. The corresponding chemical cost in California, assuming all other conditions equal, would be $8.90 per m.g.

It appears that ferric chloride and chlorine can be used over a wide range of doses, i.e., high ferric chloride doses require little chlorine and high chlorine doses use but little ferric chloride. The balanced cost appears identical over a rather wide range.

3. Sludge Conditioning.

At the Long Beach Convention of the California Sewage Works Association in October, 1930 (see California Sewage Works Association Journal, Vol. III, No. 1, page 44), the author in speaking of the work at the Griffith Park Reclamation Plant stated, "It is proposed to install a mechanical filter to dewater the digested sludge and to do away with all sand beds. This method appears to be cheaper in both installation and operation costs and eliminates unsightly sludge dry-

ing beds". Mechanical filtration of digested sludge was started that year and in the following year experiments were made on activated sludge. Three types of vacuum filters were used—Dorr, Oliver and Wright. Previous to this time Oliver filters had been developed for activated sludge at Milwaukee and Oliver and Press filters at Chicago. Press filters had still previously been used at Worcester and Providence.

Since 1930, and particularly since 1932, the idea of filtering digested sludge, originating here, has resulted in widespread experimentation elsewhere. This trend has been justified because of the recent developments in most sewage treatment processes resorting to digestion of sludge. However, the cost of chemicals in conditioning digested sludge appears to be identical with the cost of treating raw sludge so far as dry solids in the incoming sewage are concerned. The result of the Griffith Park Reclamation experiments indicated that digestion would not be used in the design of a large plant and that fresh sludge (90 per cent water) mixed with concentrated activated sludge (94 per cent water) would be dewatered directly without digestion. This is clearly the trend so far as chemical treatment of sludge is concerned. At Winston-Salem raw sludge is successfully conditioned and dewatered with vacuum equipment.

Chemical treatment of sewage employs relatively low doses and is insufficient to condition the sludge which is produced. Sludge requires more concentrated dosages, but the work at Chicago, Baltimore, Columbus and Cleveland show that chemical conditioning of digested sludge is practical. Concentration of activated sludge under a chlorinated top water blanket which requires about 15 lb. of chlorine per m.g. of sewage treated but which chlorine is sufficient in the thickening tank overflow to disinfect the effluent of the plant was developed at the Griffith Park Reclamation Plant and is proving its worth at Phoenix. Chlorine can also be used to advantage in concentrating raw sludge.

The main argument for digesting sludge is so it can be dried on open sand beds. However, there is no general locality even in Southern California where sludge can be dried at all times of the year without inconvenience. If sludge is to be dewatered to 35 per cent water open sand beds are valueless. Sand bed sludge is usually removed at 50-70 per cent water. But even to get 50-70 per cent moisture sludge cities must resort to greenhouse drying or storage of sludge in the winter. It can be shown that the installation and operation costs of efficient drying of digested sludge on sand beds varies between $8.00 and $9.00 per ton of dry solids as compared with a total of $12.50 per ton of dry solids for vacuum filtration. The operation costs of the former are $4.00 to $5.00 per ton of dry solids for sand bed drying as compared with $5.20 per ton for vacuum drying.

In conditioning digested sludge for vacuum filtration either lime or ferric salts with or without lime are successfully used. A plant using lime coagulation for sewage would condition its sludge with additional

lime such as at Winston-Salem. The lime cost of conditioning its sludge is $1.30 per m.g. Ferric chloride if used alone requires about 8 per cent in weight of the dry solids in the sludge, which costs here about $4.50 per ton or approximately $5.00 per m.g. By adding 15 per cent lime the ferric chloride dose can be reduced to 5 per cent, in which case the chemical costs are reduced 10 per cent.

Except possibly for large plants vacuum filtration of either digested or raw sludge will not become common. Chemical treatment of raw sludge and rapid dewatering on sand beds properly designed for that purpose looks more promising. It does away with the installation and operation costs of the digestor, eliminates the overflow liquor problem and effects an over-all saving in installation and operating costs. By treating the raw sludge with 5 per cent ferric chloride and 15 per cent lime, sludge will dry without odor or fly nuisance in three days comparable with digested sludge at twenty-one days. The sand filter should be designed to raise the sludge just off the sand surface 24 hr. after application and then be cut into cubes 4 in. square. This method saves $2.00 per m.g. for digestor costs, saves two-thirds of the cost of drying beds cost, which is equivalent to $3.00 per m.g., giving a total reduction of $5.00 per m.g. The added cost is chemical mixing and chemical treatment, which just offsets the indicated saving. The advantages, however, are that one-third drying area is required, beds are less unsightly, with lime present odors are controlled, sludge is disposed of quicker and the sludge has 8 per cent ammonia as contrasted with 1.5 to 2.0 per cent in digested sludge.

Naturally, sludges produced from chemical treatment of the sewage itself will have less chemical requirement for conditioning of fresh sludges and this points to an over-all saving where advantage is taken of correlating both functions.

4. Chemical Treatment as an Adjunct to Biological Processes.

This field has not been given the attention it deserves. At the Griffith Park Reclamation Plant it was found desirable to add chemicals to the activated sludge process as follows: lime to the raw sewage whenever the pH dropped below 6.5, lime equal to 150 lb. per day into the reaeration tank to control bulking of activated sludge and to inactivate enzymes, chlorine into the reaeration tank at a rate of about 15 lb. per m.g. to keep the bacterial count in the reaerated activated sludge between 500,000 and 1,000,000 per c.c. and occasionally to add ferric chloride, copper sulphate, and iron oxide to control types of biological organisms in the sludge as well as the weight of the sludge. The total cost of chemicals other than disinfection of the final effluent which improve and control the activated sludge process is less than $1.50 per m.g. It stabilizes the activated sludge process and insures adequate treatment under all operating conditions. More and more attention must be given to these features.

5. Complete Treatment by Chemical Methods.

An effort is being made to develop chemical processes which will produce effluents equivalent to an activated sludge effluent. At Chicago the Guggenheim Brothers, Inc., are attempting to develop the use of zeolites to remove ammonia in a well chemically clarified sewage. Clear sewage passed through zeolites will result in calcium, magnesium and ammonia being trapped in the zeolite. Calcium and magnesium are removed first and ammonia last. However, it is reported that ammonia can be also removed and be recovered from brine used to regenerate the zeolite. The cost of salt for regeneration and steam for ammonia recovery has been estimated at $3.68 per m.g. based on Eastern prices. The process is untried as yet and can only be justified in case a market for recovered ammonia is found.

Interesting attempts are being made to develop adsorptive clays and suitable activated carbon which can be used to adsorb dissolved impurities in solution. Undoubtedly considerable research along this line will shortly be taken. No cost data are now available.

Stevenson at Palo Alto believed he could effect a removal of 95 per cent of the B.O.D. in raw sewage by using 250 lb. of chlorine and 200 lb. of anhydrous ferric chloride per million gallons of sewage using coagulation after preliminary settling. Since at least 30 per cent of the B.O.D. in raw sewage is in dissolved organic matter, it is apparent that at least 83 per cent of the dissolved organic matter was removed, in which case this modified process becomes comparable with the activated sludge process. If chlorine can permanently oxidize 80 per cent or more of the B.O.D. of the dissolved organic matter then this modified process has more merit than it apparently is being given. The chemical cost of such treatment is $11.25 per m.g.

As yet these so-called complete methods of sewage purification as contrasted with stable treatment have not yet been demonstrated in regularly operated plants. It is a field which will continue to interest the sanitary engineer for some time to come.

Chemical Treatment vs. Activated Sludge

It is necessary after assembling much of the data on sewage treatment to determine just what has been accomplished at the different plants, which were special conditions encountered, what are limitations of different processes and what are corresponding costs in California. The factors which vary in different parts of the country need to be carefuily taken into consideration.

1. Price Variations.

The wide difference in cost of Eastern and Western chemicals militates against some types of chemical treatment. The following are prices reported by different plants in actual operation:

	Average Cost Per Ton Carload Lots		Per cent Cal. cost is higher
	East	California	than East
Lime (CaO)	$10.00	$12.00	20.00
Ferrous sulphate	17.50	27.00	54.00
Ferric sulphate	20.00	45.00	125.00
Ferric chloride	30.00	56.00	86.00
Chlorine	36.00	65.00	81.00

It is noted that the smallest difference is in the cost of lime and the greatest is for ferric sulphate. The latter costs over twice the amount which has to be paid in the East, hence militates against its use here. The high cost of ferric chloride and chlorine here also stands as an obstacle in way of their general use here.

The cost of chemicals in California is being lowered steadily as markets develop, but it cannot be hoped that they will ever reach the present Eastern level because the East is now experiencing a tendency to higher levels because of compliance with "New Deal" standards. As labor costs increase, chemical costs are certain to increase. Experience has shown that chemical costs, while they are fairly stable, are also subject to considerable fluctuations.

The cost of clarifying settled sewage by the activated sludge process is largely the cost of electrical power. Power costs in some parts of the country are still high, namely, two to three cents per KW-hour. In California a moderately sized activated sludge plant averages $.0085 per KW-hour. Electrical power is gradually becoming lower all over United States and in California it may ultimately reach $0.005 per KW-hour. It is not subject to any great variations in any given community.

When comparing the costs of chemical treatment vs. activated sludge the cost of chemicals based on known dosages for any particular location must be balanced with the power charges for the amount of air required for the activated sludge process.

2. Variations in Dosages for Type of Sewage to Be Treated.

The alkalinity of the sewage both as affected by the water supply and underground leakage into the sewers, together with carbon dioxide in the raw sewage, makes marked differences in coagulant dosages. For instance, at Winston-Salem a lime does of 1500 lb. per m.g. raises the pH to 9.0 and gives 40-60 p.p.m. excess lime. The alkalinity of the water supply is 17 p.p.m. and the hardness of the sewage is 25 p.p.m. The average alkalinity of water in California is probably 200 p.p.m. and the hardness of sewage is about 250 p.p.m., of which half would be magnesium hardness. The total lime dosage equals that necessary to absorb carbon dioxide, react with the alkalinity, react with magnesium to satisfy the alkali demand of the organic matter and an excess of 40 to 60 p.p.m. for excess causticity. The lime dosage here would have to be increased from 1500-3200 lb. per m.g.

With the price differential the reported cost at Winston-Salem of lime for clarification would change from $7.50 to $19.20 per m.g.

Alkalinity also reacts with ferric salts and a certain greater amount of ferric chloride is required for higher alkalinities. With the presence of slightly un-ionized organic acids in sewage the amount of ferric salts is also increased. There is no adequate data yet available to evaluate actual differences, but it does explain some of the apparent discrepancies found at different plants. Some raw sewages contain iron such as the Shades Valley plant at Birmingham which affect the amount of chemicals required.

In activated sludge treatment the amount of air required must be proportioned to the strength of sewage to be treated. Generally speaking, a uniform amount of air is added day and night with the thought that over-aeration at night balances under-aeration on the peak flow. In chemical treatment the chemical dose must be always higher than the anticipated amount before the next change is scheduled. The rate of dosing at the high flow is usually double that at the low flow. The chemical process is, therefore, far more sensitive than the activated sludge process and slight overdosing most of the time is imperative.

3. Fundamental Difficulties.

All processes for the treatment of sewage involve fundamental difficulties and limitations. For instance, clarification by lime where the pH is left at 9.0 causes some of the colloidal solids to go into solution and in some cases dissolved solids have been higher in the effluent than in the influent. Sewage so treated is "pickled" so far as ordinary bacterial activity is concerned and if adequate dilution or natural aeration is not provided anaerobic conditions will set in as the pH lowers toward neutrality.

Use of iron salts invariably results in iron being contained in the final effluent. This is particularly true where ferrous sulphate and lime are used. Ferrous and ferric salts cannot remove all the colloids where the reaction takes place in a fixed pH range. Most protein colloids have excess negative charges, whereas starches have excess positive charges. To really remove colloidal organic matter sewage would have to be coagulated at pH 8.5 or above and then be re-coagulated at pH 4.5 to really effect any considerable removal of colloidal material comparable with the activated sludge process. A sewage coagulated at pH 7.0 may become clear but in the meantime have actually put proteins and starches from a colloidal state back into solution. Hydrogen sulphide in the raw sewage also increases iron dosages. As yet no method has been devised to feed iron salts automatically to take care of chemical requirements due to strength variations in the sewage and variations due to industrial wastes and ground water. Why iron recirculated sludges heavily treated with chlorine are so liquid needs further study and such sludges are more difficult to concentrate than activated sludge. The entire field of recirculation and regeneration of sludges has yet to be thoroughly investigated.

Zeolites are broken down rapidly with pH value below 7.0, necessitating use of lime to keep the pH at all times above this value. The efficacy of zeolites in removing ammonia in sewages having a hardness of 250 p.p.m. could not be demonstrated at the Griffith Park Reclamation Plant. There it was found that only 50 per cent of the ammonia could be removed. Even if zeolites did remove all of the ammonia there is no reason to assume that other non-nitrogenous dissolved putrescible substances were also attacked.

Chlorine lowers the pH materially. In waters with a high alkalinity a dose of 25 lb. of chlorine per m.g. will reduce the pH from 7.0 to 6.9. What would be the reduction of pH by using 250 lb. of chlorine per m.g. has not yet been demonstrated.

A sewage treated with heavy doses of iron compounds and chlorine also reduce the pH very materially to the point at which the sewage effluent becomes "pickled". It would seem fair to require the addition of lime to restore the pH to 7.0 would be a justifiable cost of chemical treatment.

The activated sludge process without chemical control will bulk, be upset by pH values below 6.5, and will require excessive amounts of air when bacterial counts in the activated sludge are high.

Both chemical treatment and activated sludge treatment require about the same amount of labor and type of supervision.

4. Misleading Claims.

Manufacturers, eager to provide outlets for their products, are apt to set up ideal experimental stations which are operated with the best of care and the results are then compared with activated sludge in ordinary operation run under strict economy. Mr. Pearse at Chicago pointed this out in connection with the Guggenheim results. At Palo Alto chemical treatment was declared superior to the activated sludge process on the assumption that the sludge from both processes could be handled at the same cost. The Palo Alto sludge when high chlorine doses were used apparently had a water content of 98+ per cent, whereas the combined raw and concentrated excess activated sludge need not exceed 93 per cent. Since the former has three times the volume of the latter it is evident that the two processes were not reduced to a comparable basis.

Many of the reports of plants are extremely misleading. For instance, the Shades Valley Plant report gives results of actual operation on a 1 m.g.d. basis but sets up the actual cost as to what it would have been if the plant had treated 2 m.g.d. and had been shut down half of the year. Naturally the annual cost per million gallons becomes one-fourth of what it should have been so far as comparisons with other processes are concerned.

Other claims are that effluents are purified when actually colloidal substances are put back into solution and the appearance gives a false indication of actual purification.

It is not believed that any of this misleading advice is intentional.

Engineers themselves are prone to give out advice containing even greater errors. The fact remains truer than ever that each case should be figured out from all angles.

5. Chemical Treatment *vs.* Activated Sludge.

In order to show where chemical treatment instead of activated sludge and vice versa should be used it is necessary to assume several different examples. First assume that 60 per cent removals of solids are required. Should a clarifier be used with a settling rate of 600 g.p.sq.ft. per minute be used or should a clarifier with 30 per cent removal be used and chemical treatment be added to increase the efficiency up to 60 per cent when required? It is further assumed that the plant has a capacity of 1 m.g.d. The saving in the clarifier installation cost would be $1.00 per m.g., but the added chemical cost would be five to ten times this amount and it would pay only if the added removal was necessary about one month out of a year.

Second, assume that a sewage with 250 p.p.m. of suspended solids and 200 p.p.m. B.O.D. requires about 85 per cent removals of suspended solids and B.O.D. Which is cheaper, chemical treatment or activated sludge? The installation cost of activated sludge would be 20 per cent greater than chemical treatment. Both would have the same cost of clarifiers and sludge disposal methods. The chemical storage, mixing and coagulating tanks would be one-half of the aeration capacity and costs. The chemical feed devices would equal the cost of air blowers. Since aeration costs about $20,000 per m.g. capacity added overhead the cost of the activated sludge process over chemical treatment would be $2.00 per m.g. Operating labor costs, miscellaneous items, laboratory control, depreciation and maintenance should be the same for both methods. It then is necessary to compare the chemical cost on one hand with the combined chemical cost and power cost of the activated sludge process. The following table gives the costs for different coagulants:

	Dose Lb. per m.g.	Per m.g. California price	Per m.g. Eastern price
Lime	3200	$19.20	$16.00
Ferric chloride and Chlorine	142.5 and 80	6.60	3.50
Ferrous sulphate and Chlorine	600 and 85	10.70	7.53

In the activated sludge process 15 h.p. can generate sufficient air to give 85 per cent removal. This is equivalent to 11.1 KW, which at $0.01 per KW-hour costs $2.66 for power. This added to the overhead differential in installation cost plus $1.50 for chemical costs in controlling the activated sludge process gives $6.16 for activated sludge as compared with $6.60 for chemical treatment. Activated sludge is therefore cheaper. With power in the East at $0.02 per

KW-hour and lower chemical costs, the differential is in favor of chemical treatment over the activated sludge process.

Next assume that 95 per cent removals were desired. The chemical cost using 250 lb. of chlorine and 200 lb. of ferric chloride per million gallons would be $13.72. The combination of 395 lb. of ferric chloride and 70 lb. of chlorine per million gallons as indicated by the Shades Valley plant would cost $13.28. Compared with this would be the cost of 20 h.p. per m.g., which is $3.30, added to $2.00 per m.g. for overhead costs of the additional installation cost over chemical treatment and $1.50 for chemical control, giving a total of $6.80. It is obvious that the activated sludge process is cheaper in California for such removals. In the East the chemical treatment for equivalent amounts would be $7.18 compared with activated sludge at $9.00 per m.g.

It is apparent that chemical treatment has a large field in the East where power costs $0.02 per KW or more, where sewage is weak and chemicals are cheap, but in California, where power averages $0.01 per KW, alkalinities and suspended solids are high, the activated sludge process is decidedly cheaper.

Probable Trend

Chemical treatment cannot succeed in California as a competitor to plain sedimentation up to 60 per cent removals or of activated sludge from 85 to 95 per cent removal of suspended solids and B.O.D. In the East local conditions will determine whether one method of treatment should be used over the other.

The probable trend both in California and in the East will be to combine the good points of both processes. Improvements in degree of treatment affected and reduction in costs will be through the polishing up of a combination of both processes. For instance, consider the advantages of such a process:

1. pH adjustment of the raw sewage to keep the value between 7.0 and 7.5. This will give better sedimentation by absorbing carbon dioxide and will prevent upsetting of the activated sludge process.
2. Preliminary clarification to remove 60 per cent of the suspended solids and half of the B.O.D. in clarifier designed on a basis of 600 g.p.sq.ft. per day.
3. Splitting of the flow into halves or other ratios which for any given plant are better and
 (a) Coagulate, mix and flocculate with ferric chloride and chlorine and followed by settling with sludge returned the raw sewage, increasing the removal in the first clarifier from 60 to 70 per cent. The effluent from this half of the process would have 95 per cent removal, low pH, low dissolved oxygen, but a good appearance.

(b) The second half would be treated parallely in an activated sludge plant of 6 hr. detention, sludge reaeration and sedimentation. Lime at 150 lb. per m.g. would be added to the reaeration tank. Also, final effluent would be added to the reaeration tank to dilute its volume and give an equivalent chlorine dose of 15 lb. per m.g. of sewage treated to the reaeration tank. Excess activated sludge would be concentrated with chlorine in a separate tank. The effluent from this half of the process would be high in dissolved oxygen, have a good appearance, and have a high pH.

4. Fresh sludge containing the chemically deposited sludge mixed with the excess activated sludge would be conditioned with ferric chloride and lime for rapid dewatering on sand beds equipped for raising of sludge after 24 hr. on the beds and cutting of sludge during the drying process into cubes. There would be no overflow liquor. This process would probably remove half the sludge at 90 per cent water, 70 per cent of the remaining half at 90 per cent water and 30 per cent of the same half as 94 per cent concentrated activated sludge. This is equivalent to all the sludge at 91 per cent water. An activated sludge plant rarely produces a combined sludge of 93 per cent.

5. The final effluent from the chemical and activated sludge portions would be combined and the chlorine in the overflow of the activated sludge concentration tank would be used to disinfect the final effluent.

DISCUSSION OF PROBABLE FIELD OF CHEMICAL TREATMENT

By B. D. PHELPS*

This remarkably well thought out paper should be studied by all interested in chemical treatment of sewage in any State.

Engineers should be very thankful to the large chemical companies for their efforts to create and develop a new or a little used method of sewage treatment. The financial condition of most cities will not warrant such expenditures; thus the field of sanitary engineering would be in a calm. Let us read and study these reports and, like all advertising matters, use the best parts of the results obtained and carry on. This new field, coming as it did just when the royalties for activated sludge were being held over our heads, is indeed a relief even though for only a short time. Competition is more than likely to reduce all royalties on all methods later.

Construction costs should be very much less than sprinkling filter beds due to the condensed plant. It will be possible to construct smaller units at a time and thus save on the initial cost; also when new ideas come up to incorporate them in the design instead of having a large initial plant full of obsolete ideas.

Mr. Goudey stresses the additional cost of chemicals in California; that is not so important in a small plant say of 1 to 3 m.g.d., at say $365 to $1085 per year additional for chemicals.

* Assistant Engineer, City of San Diego, Cal., Exposition City, 1935.

Power rates have not reached the low levels in all cities that he quotes, so that power consumption is still one item that should be considered at the plant location.

The most important reason to turn to chemical treatment is the flexibility of the method. This was proven in almost all its forms at Shades Valley, where at least five different methods of operation are provided. (See Water Works and Sewerage—March, 1935.)

The operation results of any plant, regardless of cost, must be considered at the start. Should we continue to pay for a plant that causes untimely upsets such as has occurred in our best regulated activated sludge plants, causing odors that bring the wrath of the adjoining property owners with the ever dreaded law suits, or shall we try a new method?

In almost all California cases, except three or four, the plant to be considered will be run by a general city sewer foreman, one who is mechanically trained and not a chemist or a bug trainer. Thus chemical treatment appeals to him; he soon sets his $FeCl_3$ doses so that the proper amounts are added to his tanks when his peak flow is on and when the sewage is strong, it is purely mechanical to him to get results. His applications of chlorine are taken care of in the same manner and the results are a sweet, neat plant with an effluent sufficiently chlorinated to kill bacteria and be turned loose in the stream bed.

The future of chemical treatment plants will undoubtedly be the combination of many other methods. The City of San Diego constructed a small experimental chemical treatment plant and the results brought out the following facts:

That a chemical treatment plant designed for flow of sanitary sewage only can be constructed cheaper than many other types of treatment plants. The designer should take careful sample of the proposed sewage to be treated and find out over a period of time just what kind of sewage must be treated. For example, strong domestic, weak sewage, sewage with seasonal wastes from packing plants, laundries, gasoline or oil industries. These will sooner or later upset the plant and should be provided for in the design.

The usual bar screen should be followed by a small skimming tank of about 10 to 20 min. retention, where aeration should be used at the rate of .1 cu. ft. per gallon to cause the oil or grease to rise to the surface where it can be removed to insure a clear effluent.

The next step in the plant would be a mixing tank with a retention of 30 min. with equipment to mix the sewage with a circumferential speed of the paddles of about 2 ft. per sec. Into this tank would be mixed the return sludge from the final settling tank, or it could be returned at the bar screen.

The flow from the mixing tank would go to the primary settling tank with a 1 to 1½-hr. retention, the sludge to be drawn off to the sludge digestor tank. The effluent from the primary settling tank should be run to the secondary flocculator where retention of 30 min. will be allowed to mix the chemcials with mixing equipment running at circumferential speed of 1 ft. per sec.

The final settling tank should have baffles at each end to stop short circuiting of the floc and have retention period of from 1½ to 2 hr.

As a later experiment, the final effluent was run through a contact sand filter with rather discouraging results due to clogging. A change to a rapid sand filter with a constant head of water over the sand, gave splendid results, with a clear, sparkling effluent, that could be used for irrigation.

The addition of chlorine at various points on the plant should eliminate odors and produce results that would please any layman.

The chemical dosage prior to the secondary flocculator should be accomplished by a mechanical feeder proportional to the flow and the concentration of the sewerage. Preceding the second flocculator there should be some type of a flash mixer to thoroughly mix the chemicals and the effluent from the primary settling tank.

The above experiments gave results comparable to other cities and while on a small scale, the different ideas worked out will prove of value in the design of a larger plant. The amounts of $FeCl_3$ required checked the statements of the Stevenson as used at Palo Alto and gave rather an optimistic picture for chemical treatment in San Diego, with our higher rates on power and the possibility of cheaper chemicals due to the cheap freight rates by steamship.

DISCUSSION

R. A. Stevenson: "Mr. Goudey stated that he was on a spot. I am too. There is no intention to enter into a controversy of the relative merits of different plants, since this is a paper entitled 'The Probable Field of Chemical Treatment of Sewage in California.' However, in reference to Mr. Goudey's paper I would like to say that I have found that a sewage of high alkalinity requires less iron than one with low alkalinity. I am in the chemical business and almost daily have occasion to hear one quote prices from both East and West. The statement that prices in the East are much lower than those in the West is not quite true. The price differential is not so great. In the first place the figures quoted are for carload lots on these chemicals. I think you will agree with me that 90 per cent of the chemical users will not be buying in carload lots.

"I agree with Mr. Goudey when he says that in the future the probable field of chemical treatment is where the simple removal of suspended solids is all that is required. I don't think it is proper to compare the ultimate results obtainable by activated sludge with the results of chemical treatment. Analysis of sewage from all over the United States indicates that in most cases a removal of 75 per cent of the B.O.D. and 90 per cent of the suspended solids is all that is required. Chemical treatment will accomplish this removal, and that is all that I have ever claimed for it. Its field is to fill the gap between plain sedimentation and activated sludge. If kept in its own field it will fill the main demand for treatment.

"There is a place for chemical treatment on the Pacific Coast. Wherever there is a plant whose requirements are such as I have stated, chemical treatment has a place there."

R. F. Goudey: "I would like to touch on the price of chemicals. I have quoted prices that have actually been given to treatment plants in the East and those given to treatment plants in California. The price of ferrous sulfate of $17.50 per ton is for the Shades Valley plant, and that is the price given in a published report from that plant. Chlorine at $36.00 per ton is the price actually being paid at an Eastern plant. The lime price which I quoted is the price paid by the Winston-Salem plant.

"In hastily going over my diagram of the proposed treatment method, I failed to bring out the chief reason for this process. The real problem in sewage treatment is the separation of the sludge from the water. The sludge problem has been the bugbear everywhere. In the division of the flow which I have shown, the activated sludge initially has a water content of 98 or 99 per cent, and this is thickened by use of chlorine to about 94 per cent and then mixed with the chemically precipitated sludge at about 90 per cent. The total sludge would have a percentage of 91.

"In any new job where the engineer must weigh chemical treatment versus the activated sludge process, it is necessary to take into

account the actual cost of chemicals delivered at such a plant and investigate the cost of power."

T. R. Haseltine: "I think we all know from past meetings that if you get operators together they argue back and forth and each has in mind his own plant. There is no hope of coming to any conclusion. Every man has his own opinion."

J. F. Smith: "I question the authenticity of that $36.00 chlorine. I don't believe that there is any such price at this time in the East. As for copperas, I can well imagine that in Birmingham they can get it for $17.50 per ton, if not less, as it is a by-product of the steel industry."

R. Pomeroy: "The chemical treatment of sewage has been studied and tried out for many years. It is unfortunate that with these years of experience so little reliable information has been accumulated to show just what chemicals will do, or to enable one to predict what can be expected in a given case. One reason for this condition is the form in which the results are usually given. It is customary to refer to the overall reduction of B.O.D. and suspended solids, but a large part of this removal may be due to coarse solids which would settle readily even if chemicals were not added. Referring again to the experiments conducted at the laboratory of the Los Angeles County Sanitation Districts, a comparison was made between a sewage containing 160 p.p.m. of suspended solids and a sewage containing 2200 p.p.m. of suspended solids. The difference between these two samples was due largely to coarse solids which had temporarily stranded in the sewer. When these two samples were subjected to the same chemical treatment, these was no significant difference in the effluent. Obviously, per cent removal of the solids originally present would have very little meaning.

"Another effect also needs to be taken into account. That is the effect of flocculation without the addition of chemicals. We performed some experiments about two years ago in an installation designed to treat a million gallons a day. It was found that flocculation and sedimentation without the addition of any chemical reduced the B.O.D. 10 per cent and the suspended solids 12 per cent beyond what would be removed by simple sedimentation. In the recent laboratory experiments flocculation without chemicals reduced the B.O.D. 26 per cent and the suspended solids 41 per cent. The greater effect in this case may be due to the fact that the samples were agitated very violently before treatment, which would cause a greater dispersion of the solids than would be the case in the original sewage. Because of this effect, chemicals may sometimes receive credit for effects which are in part due to flocculation alone. In evaluating the effect of chemicals, comparisons should be made with samples which have had identical treatment in all respects, including flocculation, except that the chemicals are not added. By making comparisons of this sort, our experiments showed that 1 grain per gallon (17.2 p.p.m. or 143 pounds per million gallons) of ferric chloride reduced the B.O.D. 15 to 30

per cent and twice this dosage reduced the B.O.D. 25 to 40 per cent."

H. O. Banks: "I have made some experiments along the same line, except that I used the oxygen consumed test instead of B.O.D. to measure the strength of the samples. These experiments have confirmed what Mr. Pomeroy has reported as to the effect of flocculation without chemicals."

R. A. Stevenson: "This effect has been known in water purification for a long time, and is called 'autogenous coagulation.' We took it into account in our experiments at Palo Alto."

T. R. Haseltine: "I would like to ask if this effect was observed on samples which were first settled and then flocculated, or on samples which were flocculated before settling."

R. Pomeroy: "If a sample is first settled and then flocculated, a further quantity of solids will then settle out. If the sample is flocculated before settling, then a greater amount will settle than if it were not flocculated. In other words, the effect is observed either way.

"I should like to mention also our results on the effect of settling before addition of chemicals. It is usually stated that the sewage should be settled before addition of chemicals, although this seems to be largely a matter of opinion and not a conclusion based upon thorough experimentation. We made several tests on one sample of sewage, using various dosages of lime and of ferric chloride, and found that preliminary settling made no difference in the final product. One cannot place much reliance upon the conclusion from a single experiment of this sort, but it at least indicates that further study along this line is desirable. Different results may be found under other circumstances or with another sewage. In this question, as in all others in which methods of treatment are under consideration, each plant has to study the problem from the point of view of its own kind of sewage and its own requirements."

H. O. Banks: "I would like to bear out what Mr. Pomeroy says about preliminary settling. As far as I can tell, there is no advantage in settling before addition of chemicals."

E. A. Reinke: "What Mr. Pomeroy says about each operator or investigator seeing the problem from his own point of view applies with equal force to engineers and equipment men. Everyone seems to see his side of the question or argument. I was recently talking about sewage disposal in Denver. They have made a study of comparative costs of trickling filters and activated sludge. Due to local price conditions, trickling filters are found to be substantially cheaper in Denver, although this is not generally the case."

A VENTURI-TYPE METER FOR SEWERS

By H. K. PALMER and F. D. BOWLUS*

It often happens that the need for measuring sewage flow does not appear until after a sewer has been built and placed in use. While an ordinary Venturi meter can be placed very easily in a pipe running full and under some pressure, in an open canal or a pipe running only partly full it is necessary to make a break in the grade and a change in the cross-section. It is evident that in an existing sewer laid on a flat grade several feet under a street, such a procedure would be very expensive.

A rough estimate of the flow may be made by merely measuring the depth at some point and using a rating curve to convert the depths to second feed or millions of gallons per day. Such a rating curve can be drawn either by assuming a coefficient of roughness and carefully measuring the slope, or by actually measuring the velocity at several depths. A rough estimate can be so made if no obstruction develops below, or no change in roughness or cross-section occurs after the curve is made.

Weirs have been standard devices for a long time, giving satisfactory results when properly placed, but it is a temptation to overlook the required rules in building them. Present day attitude is aptly stated by Prof. H. W. King of the University of Michigan in an article published in the **Transactions** of the American Society of Civil Engineers. T.A.S.C.E. (Vol. 93 (1929) pg. 1111.)

The late Frederic P. Stearns makes the following statement:

"In view of these large differences in the results of carefully conducted weir experiments, two conclusions seem to be warranted:

(1) That in the present state of the air the weir is not an accurate instrument for the measurement of water.

(2) That the art should be developed so that the causes of the variation in results may be discovered and eliminated."

The first of these conclusions holds today. Later experiments only raise the query as to whether it is worth while to follow the suggestion contained in Mr. Stearns' second conclusion, or whether it will be more profitable in the end to let the sharp-crested weir rest temporarily and take up the investigation of other and more promising means of measuring flow water."

The hydraulic conditions required in the setting of a weir in a sewer are such as to make a proper installation almost impossible. These conditions limit the flow to about 40% of the capacity, and stilling the water above the weir soon causes a deposit which not only changes the constants of the weir, but it is often the source of other problems, one of which is the septic condition which it sets up.

The theoretical formula given in text books, while very simple and apparently correct, requires a correcting factor amounting to approximately 0.6 to bring it into agreement with observations. This variable factor depends upon the condition of the crest plate, the height of the crest above the invert and the depth over the crest. Apparently the variations in this so-called constant are due to energy losses and it is only reasonable to suppose that if these can be eliminated the inaccuracies will also be eliminated.

*Chief Draftsman, Los Angeles County Sanitation Districts and Resident Engineer, Los Angeles County Sanitation District No. 2.

The Parshall meter has become a standard method of measurement for irrigation canals and well deserves its popularity for wide conduits where the necessary drop in the invert can be provided. The point of measurement is situated at a certain fixed point in the transition instead of in the conduit or canal, and thus the throat size is dependent upon the flow rather than on the canal size.

The disadvantage of the Parshall meter for pipes is the rectangular shape and the limitation of depth to 2.5 ft. Since the fomula is empirical it is not safe to use it beyond the limits of the observations upon which it is based.

The Venturi flume is a stream-lined obstruction placed in the conduit which increases the velocity in the throat because of a smaller cross-section. As designed by the authors it consists of a flat level slab on the conduit bottom between two flat sides usually set on slopes of ½:1. Aprons at both ends which form the transitions, have slopes of 3:1 with the axis of the pipe. The increased velocity is attained by means of a drop in the water surface, so the ratio of the cross-sections in the normal conduit section above and in the throat is not rigidly fixed as it is in the Venturi meter. The Venturi flume can be so made that water flows through it smoothly without turbulence and with a very small loss of head, thereby only slightly diminishing the capacity of the conduit. Such a flume, however, requires accurate depth measurements in two places, one above and the other in the throat, and the computation of the flow is complex. The flume is so designed that the water reaches critical depth in the throat and the flow can then be determined by the use of but one measurement applied to the rating curve accurately predetermined.

Water at rest in a position where it can fall to a lower level has only potential energy, or energy which is available if needed. The potential energy in each pound of water, referred to the bottom of the flume, is represented by the depth of the water in the conduit. Water in motion also possesses kinetic energy which may be derived or converted from potential energy by lowering the surface. As an exaggerated case, when water from an elevated tank flows through a nozzle attached to a fire hose on the ground below, the potential energy of the water in the tank is converted entirely to kinetic energy when it leaves the nozzle. When water flows through a conduit it is convenient to consider the total energy, which is the sum of the potential and kinetic energy.

Friction in the conduit is overcome by the consumption of energy, so the energy line must always slope down-stream, even though very slightly. In some sewage disposal plants the distributing conduit at the head of tanks is laid with a level invert so water can be made to flow in either direction. According to the standard formulae, water would not flow through such a conduit, but the difference in depth of water at the two ends compensates for the lack of invert slope.

In the Venturi flume the bottom of the throat may be actually higher than the invert of the conduit, yet the energy head line will slope downward slightly and the water surface will drop consider-

ably depending on the relative cross-sections at the two points. If the water is flowing at critical depth in the throat the height of the energy curve is fixed by the quantity, and the height will be the same, or slightly more in the conduit above the transition. If the energy head itself could be measured, that would be simple, but a float and recording device is not adaptable to energy head measurements. When the velocity in the conduit above the throat is small the velocity head is very small and the depth can be found by subtracting the computed velocity head from the energy head. A series of such depths for different quantities forms a rating curve. In general, we may say that the accuracy attained depends on the velocity of the water just above the transition; slower flow means greater accuracy.

Theoretically it should only be necessary to measure the depth of water in the throat at the point of critical depth, and attempts have been made to use this principle in connection with broad-crested weirs, but experience shows that the surface of water is not level for the whole length of a flume, and the exact point of critical depth is hard to locate.

The basic theory of the Venturi flume as described is that the energy head is a well determined quantity and can be found from the depth of the water in the pipe just above the meter. A specially built instrument called a "Differential Head Meter" indicates no appreciable loss of energy between the measuring point and the throat of the flume. Experience has shown, however, that it is necessary to make the throats rather long, about equal to the diameter of the pipe, to assure that the point of critical depth of all flows will be inside of the throat limits.

Subsequent to the studies by the authors it was noted that the Bureau of Reclamation had attempted the same method some ten years previously; and had checked the rating curve of the throat by volumetric measurements. A rating curve drawn from the Bureau's data using methods employed by the authors was in strict agreement with the curve determined by the Bureau.

The Los Angeles County Sanitation Districts conducted experiments on several flumes of different sizes and shapes in comparison with measurements made with weirs set in adjacent manholes. The results were in excellent agreement in the case of small flows, but with the larger flows there were wide discrepancies.

With the cooperation of the city of Los Angeles and the courtesy of the city of Beverly Hills, a wooden flume with a throat 10 in. wide and side slope of 0.47:1 was placed in a 21-in. sewer man-hole about 500 ft. above a 12-in. Parshall meter. The channel where the flume was placed was so irregular that it was impossible to get the transition sections to fit properly, which made it necessary to use oakum to prevent leaks. This resulted in energy losses of about 5% of the energy head at critical depth.

Allowance had to be made for a small side flow, which entered between the flume and the Parshall meter. Without allowing for transition losses twenty-seven measurements ranging from one to five second feet showed that the flume measurements were 4.5% greater than the Parshall meter with a probable error of 0.4%. A concrete measuring flume with suitable transitions would have shown a much closer agreement.

A flume 2.5 ft. wide was built by the Districts in a 5-ft. semi-elliptic sewer where it was also possible to get fairly accurate weir measurements. A study of the rating curve for the flume showed that a formula similar to the weir formula could be used on the flume if the energy head was mesaured in place of the depth. The actual formula is:

$$Q = 3.09\ L\ E^{3/2}$$

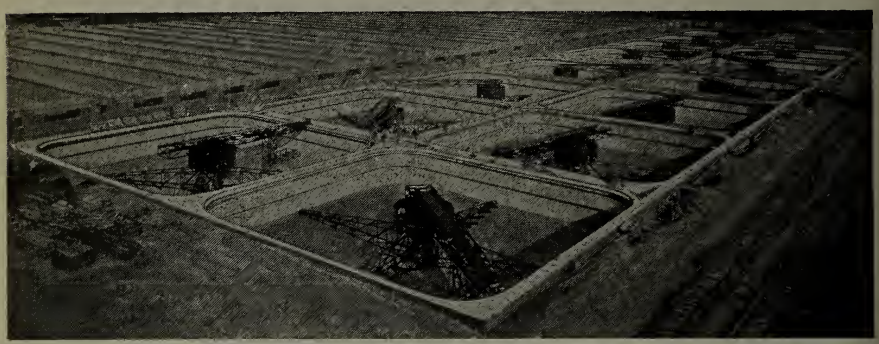
using a constant 3.09 in place of 3.33 used in the weir formula, L is the width of throat and E the height of the energy-head above the throat crest.

A method for measuring the energy head often used with weirs is to place a flat rule vertically in the water with the flat side upstream. The height the water rises up the rule is equal to the energy. Such a measurement made on a rectangular Venturi flume may be used with the above simple formula.

Unfortunately a rectangular flume does not fit a circular conduit well. It is either inaccurate for small flows or it diminishes the capacity of the sewer. The best shape is a trapezoidal one with side sloped of ½:1. Each flume must be fitted to the location, the bottom width and height above the invert being governed by the flow characteristics of the sewer. The selection of the throat size and the computation of the rating curve is a case of pure mathematics not suitable for a paper of this kind, but is to be published in the **Proceedings** of the American Society of Civil Engineers. If the engineer is willing to spend a few hours in designing the meter, accuracy of measurement can be accomplished without a sacrifice of ultimate capacity, for it is possible to design a throat that will serve as a meter station until the sewer is nearly full when the energy head in the meter will coincide with the energy head in the sewer below. Considering everything we believe the most desirable and accurate method of measuring sewage embraces the properly designed Venturi flume.

Some engineers have asked that an empirical formula be set up for these flumes, but there is such a great diversity of combinations of sizes and shapes of sewers and throats that it seems better to compute each one separately. Where it is necessary to build the throat in sewer carrying a large flow, variations from the designed shape may be found after the forms are removed. This would vitiate an empirical formula but a correction can be easily made in the rating curve. The errors to be expected, depending upon the velocity of the water above the station, under ordinary circumstances in sanitary sewers, should not exceed 3 or 4%. The chief advantage in the use of this flume lies in the fact that it can be installed in an existing sewer without altering the grade and at small expense. The raised flat slab of the throat causes a slight loss in head with only a small loss in conduit capacity. Another advantage is that a slight obstruction in the conduit below will not interfer with the accuracy of measurement so long as turbulence exists below the throat. The so-called drowning of a weir is a serious matter, and its prevention causes a large loss of head. With a Venturi flume a difference in depth above and below the throat of only an inch will give accurate measurements. A small loss of head and freedom from deposits on the upstream side, are two important factors in favor of this type of meter station for sewers or any silt-laden stream or canal.

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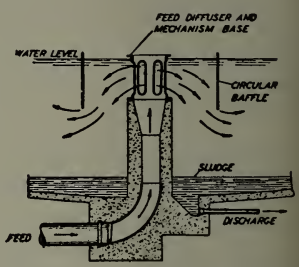


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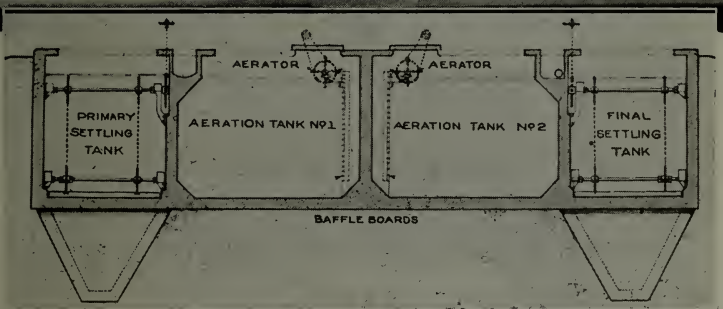
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Official Publication of the California Sewage Works Association

Vol. VIII :: 1935 :: No. 1

Minutes of the
Eighth Annual Convention
at Palo Alto and San Francisco

The San Francisco Sanitation Problem

Sewer Pipe Disintegration at Long Beach

Industrial Waste and Sewage Load
at Stockton

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Why the Gas Engine at the
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PROGRAM

Monday, September 23

PALO ALTO

Morning

8:00—Assemble and register at Community Center Building, Palo Alto.

8:30—Inspection of Palo Alto sewage disposal plant.

10:30—General assembly and reports of committees.
"The Palo Alto Sewage Treatment Plant" by H. O. Banks, former plant operator.

12:15—Luncheon at Community Center Building.

Afternoon

1:15 to 5:00—Caravan to San Mateo, Burlingame, San Francisco Jail and Golden Gate Park sewage disposal plants, and site of proposed Richmond-Sunset plant.

Evening

7:00—Dinner in San Francisco at St. Francis Yacht Club. Address by Harold Pomeroy, Mayor of South Gate, and assistant director of relief administration for Los Angeles County.

Tuesday, September 24

SAN FRANCISCO

Morning

9:00 to 12:00—Joint session with the Engineers and Street Superintendents Section of the League of California Municipalities at William Taylor Hotel. Papers and Discussions:

1. "The San Francisco Sanitation Problem," by John J. Casey, City Engineer, of San Francisco.

2. "Sewer Pipe Disintegration at Long Beach and Remedial Measures Contemplated," by J. W. B. Blackman, City Engineer-Director of Public Service, Long Beach.

3. "Importance of Industrial Wastes with Respect to the Domestic Sewage Load at Stockton," by William T. Ingram, San Joaquin County Health Department.

12:15—Informal luncheon, William Taylor Hotel.

Afternoon

2:00 to 5:00—Papers, discussions and business meeting—William Taylor Hotel.
(A) Symposium on Gas Engines Operated with Sludge Gas:

1. "Six Months' Experience with a Two-hundred Horse-Power Engine," by Carl F. Tennant, chief operator, Los Angeles Sanitation Districts.

2. "Eastern Experience with Gas Engines," by Samuel A. Greeley, Greeley & Hansen, Chicago, Illinois.

3. "Adaptation of Gas Engines to Use of Sludge Gas Fuel," by A. K. Hegeman, Sales Engineer, Smith-Booth-Usher Company.

4. "Ontario's Experience with a Gas Engine," by Austin Burt, City Engineer, Ontario.

5. "Generation of Electricity at Palo Alto with a Gas Engine," by H. O. Banks.

(B) A Discussion of Sewage Plants by Operators:
1. L. E. Malloy, San Bernardino.
2. Fred West, Stockton.
3. A. B. Shearer, Marin County Sanitary District No. 1.

(C) Election of Officers.

THE PRIZE FOR THE BEST MAINTAINED SEWAGE TREATMENT PLANT

At a meeting of the Board of Directors at Fresno on March 20, 1929, it was decided to award a yearly prize for the best maintained and operated sewage treatment plant. The prize consists of a bronze plaque on which is engraved the name of the town and the name of the operator in charge. In addition to this, the plant operator receives a cash award of $25.00. The Wallace & Tiernan Co. has sponsored the prize, which is awarded by a committee appointed by the Governing Board. Professors Hyde and Reynolds have served faithfully and continuously on this committee. The following are the winners for the various years:

1929	University of California Farm, Davis
1930	Pasadena
1931	Pomona
1932	Salinas
1933	Yosemite National Park Plant
1934	No award

In 1934 the committee was unable to make a choice, due to lack of data necessary for the basis of award.

MINUTES OF THE EIGHTH ANNUAL CONVENTION CALIFORNIA SEWAGE WORKS ASSOCIATION

Concurrently with the first two days of the League of California Municipalities' annual meeting, the California Sewage Works Association held their eighth annual business and technical session at Palo Alto and San Francisco on Monday and Tuesday, September 23 and 24, 1935.

Following registration at the beautiful Community Center Building at Palo Alto the members proceeded to the new Palo Alto sewage sedimentation and separate sludge digestion plant for inspection of the works. Returning to Palo Alto the group convened in technical session, discussed standing committee reports and listened to H. O. Banks' presentation of a paper descriptive of the Palo Alto Plant, the reasons for its selection, its operation features and costs.

Luncheon was tendered by the Board of Public Works of Palo Alto and served in the Community Center dining room. Three members of the Stanford University faculty attended the luncheon and spoke informally.

From Palo Alto the members proceeded by automobile caravan to inspect the sewage disposal plant at San Mateo, now under construction, the recently completed Burlingame plant, the San Francisco Jail plant, the site of the proposed Richmond-Sunset plant in Golden Gate Park and the Golden Gate Park plant. At the latter location the members dispersed to reconvene at 7:00 p. m. at the St. Francis Yacht Club for the annual dinner.

Mayor Pomeroy of South Gate, California, addressed the dinner audience and spoke of the position which the California Sewage Works Association should occupy in the governmental structure of the State. He stressed the importance of sound and reliable technical advice to city officials charged with the responsibility of selecting materials of construction and types of public works about which their knowledge was limited.

Mr. Pomeroy's suggestion of a discussion of the California Sewage Works Association's aims, objectives and achievements before the Mayors' and Councilmen's Section of the League met with the approval of the Association's governing board.

Tuesday morning at the William Taylor Hotel, San Francisco, the Engineers and Street Superintendents Section of the League met with the Association. San Francisco City Engineer, John Casey, and his assistant, Ben Benas, outlined what is in prospect for the City and County of San Francisco in the way of advanced sanitation and sewage disposal.

Mr. J. W. B. Blackman, City Engineer of Long Beach, discussed sewer pipe disintegration in his city, illustrating his address with views of Long Beach sewers which have been or are being destroyed by the action of oxidized hydrogen sulphide gas and related the measures which are being taken by the City to retard the destructive action in existing sewers and eliminate it in future installations.

The importance of foresight in the design of sewage plant facilities was detailed by Wm. F. Ingram of the San Joaquin County Health Department in a discussion of the overloaded plants of the San Joaquin area. He cited in particular the case of the city of Stockton where a sewage treatment plant designed for the normal population of the city was now attempting to treat sewage from a population equivalent three times as great with poor success.

Dr. Richard Pomeroy, Research Chemist, Los Angeles County Sanitation Districts, illustrated a new test for hydrogen sulphide in sewage and described its value in treatment processes and sewer line maintenance.

The Tuesday afternoon session of the Association was devoted to the presentation of a symposium upon sewage sludge gas engine construction and operation and a presentation of plant operation problems by operators. Papers by C. F. Tennant, S. A. Greeley of Chicago, A. K. Hegeman, Austin Burt and H. O. Banks were read.

A discussion of sewage plants by operators was given by L. E. Malloy of San Bernardino, Fred West of Stockton and A. B. Shearer of Marin County Sanitary District No. 1.

The meeting concluded with the election of the following officers for 1936:

A. M. Rawn	President
E. A. Reinke	First Vice-President
R. F. Goudey	Second Vice-President
J. F. Byxbee	Board of Directors, 1940
Harold F. Gray	Member, Board of Control
F. D. Bowlus	Secretary-Treasurer

Ninety-five members were registered at the session and the average meeting attendance was eighty.

Respectfully submitted,

FRED D. BOWLUS,
Secretary-Treasurer.

REPORT OF CHAIRMAN OF COMMITTEE ON LICENSING OF OPERATORS

At the spring meeting of our Association the members of the Licensing Committee discussed this subject and agreed in principle to the procedure of licensing of operators on the basis of having our Association set up standards for the qualification of the operators and the issuance of certificates to plant operators who have qualified, the certificates to be issued by our Association. While such certificates would have no legal value, nevertheless they would have considerable weight and standing and experience in other States has shown that such a procedure is very valuable in increasing the efficiency of plant operators and even enabling them to keep their positions in the face of political opposition.

R. F. Goudey, a member of our Committee, is also Chairman of a similar committee of the California Section of the A. W. W. A. It was agreed by our Committee that Mr. Goudey would prepare a tentative outline of the above mentioned plan based upon his study and familiarity with a report of the National A.W.W.A. Committee on Water Works Practice on this subject. Unfortunately, Mr. Goudey's recommendations did not reach me soon enough to allow a complete discussion by the members of your Committee, but I am sufficiently familiar with their opinions in general on the subject to incorporate Mr. Goudey's recommendations in this report; it being well understood by all members of the Committee that any comments or criticisms they may have will be welcome. I will read Mr. Goudey's recommendations which are attached to this report.

Remembering that these recommendations, so far as details go, are made as a preliminary basis for discussion, it being apparent that more study should be given by our Association to the details of the classification of sewage works operators, the qualifications required, and particularly with reference to the administration of the plan, including such details as membership of committee to administer plan if adopted, committee procedure, cost of putting plan into operation and the resulting small fee to be paid by operators desiring to be licensed.

However, it is my recommendation that our Association adopt this plan **in principle** and charge next year's Committee to bring in a detailed report as soon as possible covering the classification, qualification and administrative procedure and cost involved. If practical, this report should be submitted at our coming spring meeting and ample time left for the discussion of the details referred to.

It is my understanding that Mr. Goudey is proceeding along similar lines in connection with his recommendations to the California Section of the A. W. W. A., and such parallel procedure by the two Associations would be mutually helpful.

A. C. BEYER, Chairman
Committee on Licensing of Operators
C. S. W. A.

September 4, 1935

Mr. A. C. Beyer, Chairman
Committee on Qualification of Operators—C.S.W.A.

Dear Sir:

I am enclosing for your information the report by the Committee on Water Works Practice, A. W. W. A., dealing with licensing of water works employees. My recommendation is that parallel committees consisting of three members on each committee be appointed by the California Section, A. W. W. A., and the California Sewage Works Assn. to take care of voluntary licensing of water works operators and sewage works operators respectively. I do not approve of any legislation at this time making licensing compulsory. It is noted that in other states experience has shown it is best to first start with voluntary licensing. It is my recommendation that the expenses of the voluntary licensing committee be defrayed by small payment made by those desiring to be licensed. This might be $0.25 per person. These committees should, under the "grandfather clause," classify all of the operators who wish to obtain a rating under the voluntary classification but that subsequent to January 1, 1936, all new operators to be passed on by the committee shall pass a written examination which shall be held annually by the committee.

CLASSIFICATION OF WATER WORKS OPERATORS

There shall be three classes of water works operators as follows:

Class 1. All municipalities where sedimentation, coagulation, filtration or water softening in communities with over 25,000 population or with disinfection in cities over 1,000,000 population.

Class. 2. All municipalities where sedimentation, coagulation and filtratition are used regardless of the size of the community. All municipalities having water softening plants. All cities employing disinfection with laboratory control between 100,000 and 1,000,000 population.

Class 3. All municipalities which employ only disinfection as a process of treatment except under 100,000 population, or without laboratory control in cities of larger size. Operators in charge of shifts under direction of a one or two class operator for any of the treatment processes above mentioned.

CLASSIFICATION OF SEWAGE WORKS OPERATORS

Class 1. All communities over 25,000 population with activated sludge plants. All cities over 100,000 population with separate sludge digestion or sprinkling filter plants. All cities over 500,000 population employing any type of sewage treatment including screening, disinfection and laboratory control.

Class 2. All types of municipalities not included in first and third class.

Class 3. All cities employing disinfection only under 100,000 population and operators in charge of shifts under direction of first and second class operators.

QUALIFICATION FOR WATER WORKS AND SEWAGE WORKS OPERATORS FIRST CLASS*

Training		Experience
Graduate of a recognized college with degree in —	Sanitary Engineering	one year
	Public Health	one year
	Chemical Engineering	one year
	Civil Engineering	two years
	B. S. Chemistry Major	two years
	B. A. with courses in water chemistry	three years

— or —

Two years college	five years
Graduate of High School or less than high school education	five to ten years

SECOND CLASS

Graduate of a high school or its equivalent with additional training in water chemistry and bacteriology	two years
or	
Pass a comprehensive examination	five years

THIRD CLASS

Pass a comprehensive examination	two years

We have had some correspondence as to whether the operators should be licensed or certified. In view of a uniform policy throughout the United States I would recommend that the term of "licensing" be retained. In my opinion no license should be given to any person at this time who is not an actual operator. In some instances in eastern states unemployed men have qualified as licensed operators and have used that as a wedge to remove an existing operator by political means. You will note under the qualifications that additional training in water chemistry and bacteriology, such as could be obtained at an operators' school would permit a third class operator to become a second class operator. It thus appears that the recommendation which I have made above fits in nicely with the talk of having an operators' school to improve their standard.

R. F. GOUDEY.

On motion of Mr. Goudey, seconded by Mr. Clyde Kennedy, the following motion was unanimously carried:

That the California Sewage Works Association endorse the principle of voluntary licensing of sewage works operators; and

That a committee be appointed to present at the Spring meeting, definite recommendations for classification of operators, educational or experience requirements, and the necessary administrative details.

* All applicants for license in first class should be required to pass a written examination.

REPORT OF COMMITTEE ON OPERATORS' SCHOOL

At the spring 1935 meeting of the California Sewage Works Association held at Fresno, the undersigned were appointed a committee to investigate the subject of a school for sewage works operators, and to report thereon. The Committee received the valuable results of an investigation of schools held in other states, which investigation had been made by Prof. Leon B. Reynolds and Prof. Charles Gilman Hyde,, and which was presented at the Fresno meeting by Professor Reynolds.

This Committee has felt that the first thing to be determined was whether a school for operators in California would receive sufficient attendance at this time or in the near future to justify any university or school in attempting the difficult task of organizing and conducting the instruction. Our first step was to send letters of inquiry to municipalities, sanitary and sanitation districts and institutions, and also to operators of sewage treatment works.

One hundred and thirty letters were sent to municipalities, sanitary districts, sanitation districts and institutions, from which only six replies were received, evidencing indifference, on the part of the authorities controlling sewage treatment works, to the matter of better operation of their plants.

Two questions were asked in the letter:

Question 1: "Will you direct or advise your sewage works operator or operators to take the course?"

Question 2: "Will you defray his or their actual necessary expenses in attending the school?"

To Question 1, three answered "Yes" and three answered "No"; one (Yosemite National Park) said there was no legal way for paying such expenses; in one, the response was indefinite.

To Question 2, two answered "Yes," two answered "No" and two answers were not responsive.

Sixty-six letters, with a questionnaire attached, were sent to known operators of sewage treatment plants in the state. We received nine replies out of a total of sixty-six, indicating a slightly greater interest on the part of the operators, but not enough interest to justify proceeding with the organization of such a school at the present time.

Of the nine replies, the questions were answered as follows:

Question 1: "Would you attend a practical school for sewage works operators if your city or district paid your expenses?" Seven answered "Yes"; one answered "No"; one gave no answer.

Question 2: "Would you attend at your own expense if your city or district did not pay your expenses?" Five answered "Yes"; three answered "No"; one was indefinite.

Question 3: "Should the school be held at one location regularly or rotated in several locations?" Seven voted for a rotation of location and one for a single location.

Question 4: "How many days should the course be given each year?" Three answered "Three days"; three answered "Four days" and three answered "Five days."

Question 5: "Should the school work be divided into elementary and advanced courses?" Eight answered "Yes"; one answered "No."

Passing Question 6 for the moment, Question 7 was: "At what time of the year should the school be held?" Three answered either spring or autumn; two answered autumn; two answered summer; one answered spring and one said merely twice a year.

Question 8: "What do you consider a reasonable fee for the course?" One said $2; one said $5; one said $5 per day; two said $10; one said $15 to $25; one said 10% above the cost of giving the course and two did not answer.

Question 6: "What subjects would you want the school to teach?" Three did not answer this question but the remaining six offered suggestions.

It is interesting to note that the suggestions deal rather more with the mechanical side of operating sewage treatment plants than with the laboratory work and theory, which is the usual curriculum of such schools. To this committee, it gives a valuable hint as to what the content of such courses should really be, and also an idea as to the preferable method of instruction.

In conclusion, your Committee recommends:

1. That until such time as more interest on the part of sewage treatment works operators is shown, this Association do not proceed further with the project.

2. That some effort be made by this Association to interest the municipalities, districts and institutions in the advantages to be obtained through training of operators of sewage treatment plants, and that the facilities of the League of California Municipalities be used for this purpose.

3. That another Committee be appointed to recircularize the operators and determine whether sufficient interest in such a school has been generated to justify proceeding with the project.

4. That upon acceptance of this report this Committee be discharged.

Very truly yours,
Harold F. Gray, Chairman
A. P. Banta
F. A. Batty
John Jacobsen
A. B. Shearer
Joseph Wagner

DISCUSSION

Mr. Kennedy:

Mr. Gray's report was very illuminating. His conclusions that at the present time a school would not be practical, and that when such a school should be held that practical operation should be emphasized rather than scientific subjects, is of interest.

Mr. Gray:

In the course of time, possibly next year, the Committee on Licensing might proceed to a definite conclusion and put licensing into actual operation. At that time there will be a great deal more interest in the subject of an operator's school. It is recommended that the two committees keep in close touch. Undoubtedly the question of licenses will stimulate the interest in schools and vice versa.

Until a later date it would not be justifiable in anyone's opinion to start a school, but a committee should be appointed to carry on the licensing work with the officers of all municipalities of California. It is essential to educate city officials to require training of operators and to encourage operators to improve themselves.

REPORT OF COMMITTEE ON SAFETY REGULATIONS

In March, 1935, a letter in the form of a questionnaire was sent to each member of this committee. The answers to the questionnaire contained information on the subject of current precautions against accidents, and those deemed necessary for the future, as determined by the personal experience of the individual members of the committee. Because of the scattered residences of the committee members these replies constitute a fair cross-section of the procedure and precautions against accidents in use throughout the State.

This information, together with personal observations in the San Francisco Bay Area forms the basis for this report the object of which is to present in outline the existing procedure, regulations and apparatus used to insure safety in the maintenance of the sewers of small towns as well as of larger cities.

OAKLAND PROCEDURE

As soon as a manhole is opened, a truck, auto or wagon is parked, if possible, so as to protect it from traffic. "Men at Work" signs are placed in front and in back of the manhole. If it is not possible to park the auto or truck as described, a man with a red flag is stationed by the manhole.

The sewer is tested for gas by lowering a safety lamp into it. If gas is present, the sewer is ventilated by opening two adjacent manholes, and ventilation allowed to proceed for a day. If the sewer still shows the presence of gas, gas masks are used. Two men equipped with gas masks enter the sewer while a third watches from the top. No one is allowed to leave the foot of the ladder, if gas is suspected to be present, unless he wears a gas mask. At present, ropes are not attached to the men working in the sewer as it impedes the work.

The men are instructed orally in the above regulations. When these methods are insufficient to be used with perfect safety, the sewer is too dangerous to be worked in. If entrance under these dangerous conditions is absolutely necessary, then the better equipment and expert personnel of the Fire Department is used.

LOS ANGELES PROCEDURE

The precautions used in entering sewers to prevent accidents are covered in a preliminary set of instructions to employees from which the following excerpts are quoted:

Trucks shall be driven close to manhole to form a barrier, and proper red-flag warnings shall be used. Place two red flags about five feet away on each side of manhole.

For cleaning sewers, if there are signs of sewer gas have rope around man working in manhole and have two men at the surface.

Special care shall be used when gas is found in sewers. Open up adjacent manholes and run fresh water thru same. DO NOT ALLOW MEN TO ENTER MANHOLE WITHOUT A ROPE ATTACHED TO THEM AND HAVE TWO MEN AT THE TOP. If gas is bad, use an air pump before entering manhole and if dangerous do nothing until receiving further instructions.

PALO ALTO PROCEDURE

When men work in manholes or sumps that are more than five feet in depth they shall have ropes tied around them and shall be watched by men at the surface.

As new manufacturing wastes are continually emptied into sewers, dangerous gases and wastes are continually changing and increasing in numbers of kinds and potencies. The only sure path to safety is to keep safety regulations in conformity with the new requirements, and apparatus up to date. Eternal vigilance is necessary.

In conclusion, the chairman wishes to thank each member of this committee for his whole-hearted cooperation. The committee has been saddened by the passing of one of its members. A letter was received from Katherine H. Steward, saying that her father, Mr. O. E. Steward, had been tragically killed in an automobile accident on April 7th. Her thoughtfulness in faithfully completing her father's unfinished correspondence, in the midst of her very great sorrow, brought this sad break in the ranks of the committee very close to all.

T. F. EASTMAN, Chairman
H. E. REDDICK
W. O. CASTELLO
H. P. CORTELYOU
J. F. BYXBEE
A. B. STUART

THE PALO ALTO SEWAGE TREATMENT PLANT

By H. O. BANKS

This paper is published in the **Sewage Works Journal.**

THE SAN FRANCISCO SANITATION PROBLEM

By JOHN J. CASEY*

The growth of the city and the need for development of its recreational facilities have resulted in the imperative necessity for the construction of plants designed to treat and dispose of sewage in such a manner as to minimize bacterial infection and remove the physical evidence of sewage from the beaches in order to render them sanitary.

In order to accomplish this, it will be necessary to convey the sewage to central points for treatment and disposal. Since San Francisco is a hilly city, there are a number of individual natural drainage areas, all discharging into the bay or ocean, and these points of discharge are not always suitable for disposal from a sanitary standpoint. A brief review of the sewer system will serve to give a clear conception of the problem.

Previous to the submission of the Grunsky Report in 1899, the sewers had been built in an unsystematic manner, with apparently no consideration for economy or adaptability. Sewers for new districts were laid for those districts only. They bore no relation to the sewers then existing, and were constructed solely for the purpose of discharging into the bay; there were about 125 of these individual outlets. Brick sewers, of large size, were built in all street intersections, although the tributary lines were of small size. Many sewers were constructed of an inferior grade of cement pipe, and some sewers were merely redwood boxes.

The Grunsky Report called attention to the faults of the existing system and recommended a plan for future sewer construction that has been generally adhered to.

The general plan contemplated having six main sewage outfalls into San Francisco Bay or the Pacific Ocean, namely:

1. Visitacion Valley or China Point
2. Hunter's Point
3. North Point
4. Harbor View
5. Baker's Beach
6. Mile Rock

The city, except for certain low areas was to be served by a combined system carrying the sanitary sewage and storm flows. For the low areas, separate sewers were to be built, and the sanitary sewage was to be collected at a central point and pumped into a main discharge sewer. The sanitary sewage was defined as the sewage proper, ground water infiltration, and the run-off caused by rainfall of one-quarter inch in 24 hours. When the rainfall exceeds one-quarter inch, the excess run-off would be diverted through storm relief outlets to the bay, and the sewage would become so diluted by the storm run-off that it would be unobjectionable at the points of storm water discharge.

* City Engineer, San Francisco, California.

During the past 30 years, approximately $17,500,000 has been expended on the construction of new sewers, and the replacing and extending of the old sewers.

The present district system is shown on the map below. (The areas, populations, and flows of the tributary districts are as tabulated on the accompanying table.)

The Grunsky Report contemplated the discharge of sanitary sewage offshore into deep water. At the present time, most of the sewage is discharged at or near the shore line. The only offshore discharge is at Baker's Beach, where the intended purpose—disposal by dilution—has been frustrated by breaks in the subaqueous outlet pipe and by the effect of tidal currents in this location, which tend to carry the sewage to and along the shore.

In order to determine the proper program that should be undertaken, it was necessary, first, to consider the degree of pollution resulting from the present method of discharge.

The contamination from the sewage is evidenced by the appearance of sewage fields offshore, and by deposits of floating material, such as balls of fecal matter, grease, scum, milk bottle tops, etc. along the shore. A study of the extent of travel of these sewage fields showed that, because of the tidal currents, the entire north shore was polluted and also, at times, the ocean frontage along the Great Highway. Most of the sewage, except in the southeast districts, is discharged along the north shore. Since the final development of the sewage systems in the southeast districts will have to be delayed until these districts are more fully built up, it was thought that the present program should provide for the discharge along the north shore only. Accordingly, money was included in the P.W.A. Sewer Bond Issue of 1933, to provide for the initial development of a sewage disposal system for the Baker's Beach and Marina districts.

The reason for this selection was that the discharges from these districts are directly responsible for the contamination along the beaches in the immediate vicinity of the outlets, and that plans for the development of China Beach Park hinged on the treatment of sewage from Baker's Beach outfall. At the same time, the health authorities were complaining of the contamination of sewage at the Yacht Harbor, caused by the discharge from the Marina outfall, and had erected warning signs at that point.

Further studies indicated that, on account of tidal influences, the problem of treatment of the discharge from these two districts was interrelated to the disposal of the sewage discharged from adjacent outfalls. Therefore, a study of all contributory factors was required. Accordingly, when the funds from the bond issue became available in June, 1934, a Board of Consulting Sanitary Engineers, consisting of Harrison P. Eddy of Boston, Prof. Charles Gilman Hyde of the University of California, Clyde C. Kennedy of San Francisco, and Prof. Leon B. Reynolds of Stanford University, was appointed to lay out a plan for sewage disposal improvements.

In order to arrive at a definite conclusion, it was necessary to determine, first, the basic factors of flow of sewage, present and future, character of sewage, and requirements for disposal.

The quantity of sewage in any district is in direct proportion to the population tributary thereto; therefore, estimates were made of the future growth of the city as a whole, and by districts, up to 1960. These estimates were based on past growth, present density, and zoning, and were distributed according to districts to give a based total population of 1,050,000. The per capita flow varies in the various districts from a minimum of 50 gallons to a maximum of 115 gallons a day. This flow is approximately equal to the water consumption.

The estimates were checked by making actual flow measurements by weirs, and by recording the depth and computing the flow from the hydraulic properties of the sections and the grades.

The character of the sewage was determined by sampling and tests for total solids, suspended solids, volatile material, and chlorine demand.

Studies were made of the tidal currents by float measurements, bacterial tests, and dye tests.

After a thorough study of all the contributing factors, it was decided that since the sewage from both Mile Rock outlet and the Baker's Beach outlet affected the area it was desired to protect, namely, Baker's Beach, China Beach, Land's End, and other smaller beaches, and since it was not possible to obtain a satisfactory site in the Baker's Beach district, the best interests of the City would be served by combining the flows of the Baker's Beach, West Richmond, and Sunset districts for treatment in a plant to be located in Golden Gate Park.

The treatment plant, as at present designed, would make provision for a flow of 8 m.g.d. from the Baker's Beach district, and 7 m.g.d. from the West Richmond and Sunset districts, or a total of 15 m.g.d., and storm run-off for the combined districts for light rains at a 25 m.g.d. rate. The present dry weather sanitary flow is 10 m.g.d., according to actual flow measurements made last year. The future plant will have to treat an estimated maximum sanitary flow of 10 m.g.d. from the Baker's Beach district, and 17 m.g.d. from the West Richmond and Sunset districts, or an amount practically twice that of the capacity of the plant as at present designed, and in addition a storm flow at a 50 m.g.d. rate.

From the studies made to date, it appears that the plant as at present designed will consist of:

1. A structure to combine the flows from the tributary districts. This combined flow will be distributed into two lines to the plant, with an overflow back to the Mile Rock outlet for excess flows; one of these lines is for normal flow and the other for excess storm flows. Both of these lines will be prechlorinated for odor control.

2. An inlet building housing two Venturi flumes, and two mechanically cleaned bar racks, with provision for the disposition of the screenings removed, by either returning pulverized screenings to the main channel, or by pumping to the digester; and a second story for

chlorine storage, chlorinators, and blowers for the grease removal tanks, also miscellaneous equipment.

3. Three combined grit, grease, and oil removal tanks with aeration, each designed for 15 minutes holding time for a 5 m.g.d. rate.

4. Space and head for installation of tanks for mixing chemical coagulants with the sewage, if required in future.

5. Six covered clarifiers, either circular or rectangular with provision for skimming, having a combined capacity of 15 m.g.d. at the average rate of flow.

6. Separate sludge digestion tanks, heated, to provide 30 days holding time, with provision for 10 days additional storage.

7. A main building to house the administration rooms; power plant for heating; equipment for utilization of the digester gas; vacuum filter plant of two filters, and auxiliary conditioning and handling equipment; chlorinators and storage for post-chlorination; and pumping plant to handle the low flows from the Sunset district.

8. Chlorine dosing chamber to provide a holding time of 10 minutes of the average flow.

It was further decided by the Board that, for the present, the sewage from the Marina district should be pumped and discharged at the same point as the sewage from the North Point district, namely between Piers 37 and 39.

In the future, a treatment plant could be built near the North Point outlet, for the combined flows of the Marina and North Point districts. This plant would provide for coarse screening, the removal of grit, oil, grease, and such other material as could be removed by fine screens. The treated sewage would then be discharged approximately 2000 feet offshore into water 50 feet deep. The degree of treatment at this point would not have to be as complete as that at Mile Rock, since float studies show little tendency of sewage to return to the beaches. Floats released at Mile Rock landed at Land's End, China Beach, and along the Great Highway.

At the present time, the Marina Pumping Plant and discharge sewer to North Point have been designed, and the contracts will soon be let. Work is going forward on the design of the Richmond-Sunset Sewage Treatment Plant and connecting sewers and it is expected that initial contracts will be executed in the early part of next year.

The total expenditure for sewage disposal improvements, under the present bond issue, will amount to $1,300,000 and with the completion of the work the problem of sewage contamination at the Marina and Baker's Beach districts will be virtually solved and, when the final program has been completed, there will be no untreated sewage discharged at any point along the whole bay or ocean frontage.

DATA ON PROPOSED SEWERAGE DISTRICTS

District No.	DESIGNATION	AREA IN ACRES Sub.District	Total	Population in 1960	Average Flow mgd
1	Visitacion Valley		850	19,000	2.0
2	Hunter's Point		2,275	36,000	4.0
3	North Point		12,305	695,000	78.0
	3a North Point Sub. Dist.	11,260		625,000	69.0
	3b Marina Sub. Dist.	1,045		70,000	9.0
4	Mile Rock Sewer		6,825	320,000	27.0
	4a Baker's Beach Sub. Dist.	1,425		95,000	10.0
	4b West Richmond Sub. Dist.	495		25,000	2.0
	4c Sunset Sub. Dist.	4,905		200,000	15.0
5	Southwest	2,600	No Estimate		
		Total Population—1,070,000			

DISCUSSION

B. Benas:

The Marina-North Point project for the present construction involves:

1. The diversion of the sanitary sewage and light summer rainfall from the Pierce Street sewer through a drop-down diversion structure and through a connecting sewer to the main sewage sump of the pumping plant.

2. The control of the level in the sump by automatic float controls cutting the pumps in and out at set elevations with a limiting maximum elevation controlled by a hydraulically operated basin level regulator on the inlet line.

3. Horizontal non-clogging sewage pumps with constant and two-speed induction motors, with necessary valve controls.

4. Emergency hydraulic automatically operated gate valves on the inlet and discharge lines, operated from an independent auxiliary pressure system from dry floats through pilot valves, to prevent flooding of the station.

5. A surge tank on the main discharge header designed to overcome water hammer by supplying the water required to fill the void caused by the momentum of the moving sewage after the pumps have stopped.

6. A system of ventilation for the sewage sump discharging through a stainless steel flagpole, and a system of ventilation for the remainder of the plant discharging to the main Pierce Street sewer or to the atmosphere with cross connections with both systems.

7. Storeroom, toilet, and work shop.

8. Switchboard with oil circuit breaker, no-fuse switches, starters, recording and indicating instruments.

9. Sump level recorder arranged for recording at the plant, and remote indication over the telephone lines to the Richmond-Sunset Sewage Treatment Plant.

10. A sewage Venturi on the discharge line with indicating, recording, and totalizing meter in the plant.

11. Repair of the existing sewer to allow discharge of the excess storm flow over a weir to the bay and for drainage back to the sump after the storm has ceased.

12. A 30-in. lined and coated discharge sewer from the pumping plant to a point between piers 37 and 39, routed along Marina Boulevard through the Belt Line Railroad Tunnel under Fort Mason, to the Embarcadero.

13. Vents along the lower line and at the summit, the latter to serve for air relief and release.

The Richmond-Sunset project for the present construction involves:

1. The relocation of some of the sewers to concentrate that part of the flow which would not normally flow through the tunnel by gravity at a central point and the pumping of this sewage to the tunnel.

2. A diversion structure so designed that the flow from the various tributary sewers to the tunnel will not be over a pre-determined quantity and that the excess storm flow will discharge to Baker's' Beach as at present.

3. A gravity concrete tunnel approximately 4 ft. x 6 ft. 6 in. inside carrying the flow from the Baker's Beach district to the line to the treatment plant.

4. Gravity sewers carrying the combined flow from the tunnel and West Richmond districts to the treatment plant.

5. A diversion structure and gravity sewer carrying the flow from the major portion of the Sunset districts to the treatment plant.

6. The treatment plant as described by Mr. Casey.

Mr. Butler: "How do you separate the sanitary from the storm flow going to the pumping plant?"

Mr. Casey: "All of the flow goes to the pumping plant until the quantity is greater than the capacity of the pumps. When this condition occurs the basin level regulator which is set at a definite elevation causes the excess flow to back up in the main sewer and go over an over-flow weir to the bay. The over-flow weir is at the elevation of high tide so that the bay waters will not back up in the sewer.

Mr. Rawn: "What is proposed to be done with the sludge from the vacuum filters?"

Mr. Casey: "For the present it is proposed to haul the sludge to locations designated by the Park authorities for their use as fertilizer. This sludge will be in bulk and of approximately 70 to 75% moisture content. If the park cannot use all of the sludge the excess will be hauled away and disposed of in a similar manner to that of the garbage, namely by sanitary fill.

Mr. Allen: "What chemicals are proposed to be used in conditioning the sludge before vacuum filtration?"

Mr. Benas: "It is intended to use ferric chloride, either alone or with lime."

Mr. Batty: "Do I understand that you will discharge the effluent from the treatment plant directly at the shore?"

Mr. Casey: "For the present the treated effluent will be discharged at Mile Rock at the shore line. If found necessary, when future funds become available, an attempt will be made to either increase the degree of treatment at the plant or to carry the sewage well off shore into deep waters, or both.

SEWER PIPE DISINTEGRATION AT LONG BEACH AND REMEDIAL MEASURES CONTEMPLATED

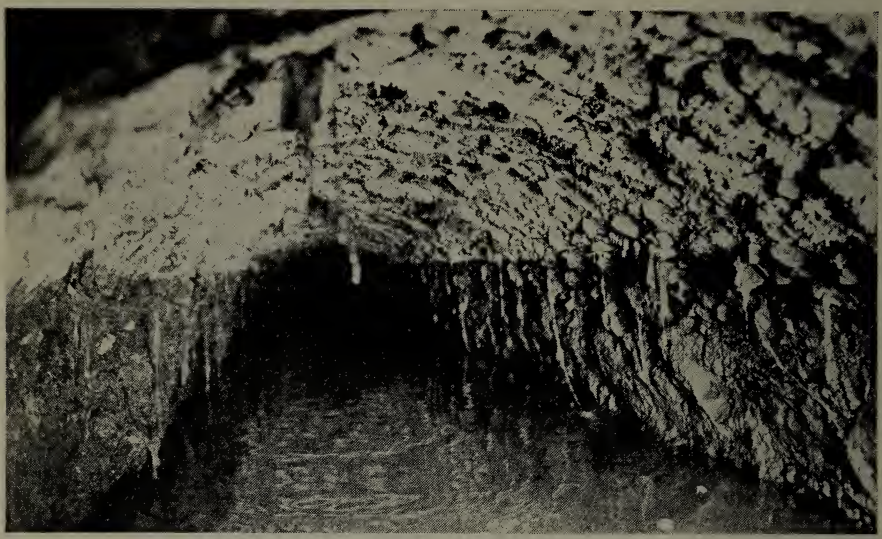
By J. W. B. BLACKMAN

It is not the purpose of the author of this article to in any way criticize the Portland cement concrete industry, but rather to indicate that there are places where concrete should not be used where the conditions are similar to those in Long Beach unless protected by some of the methods to be described later. He does not criticize the engineers who were responsible for the design of the sewers described, because it was quite probable that the type of sewage to be carried through the pipes was not known at the time the sewer was designed. For instance, a large proportion of the flow in the South Branch Interceptor is derived from the Belmont Shore area of the city, a highly developed residential district that was not **then** within the limits of the City of Long Beach, nor did it come into being for several years after this portion of the interceptor had been constructed.

The Long Beach sewage and outfall systems embrace 309.53 mi. of pipe of which amount 107.3 are constructed of concrete and the balance, 202.23 mi. of vitrified clay. The system is gravity throughout, with sewage lifted by several pumping stations from lower levels. At the disposal plant the sewage is screened, the screenings burned in an incinerator, and the effluent disposed by dilution into the sea.

The sewers in Belmont Shore were constructed in 1923 under the Vrooman Act, at a cost of $200,000. The bonds will mature in 1939. Cement pipe was used exclusively in this district, and up to the present time approximately 5.0 mi. have been replaced with vitrified clay pipe. this work having been accomplished under SERA. Sewage from the Belmont Shore area flows by gravity to a main pumping plant, to which point is also brought the flow from Naples and Alamitos Bay districts. From this main pump station the accumulated sewage is forced through a pressure line to a point some 75 ft. above the plant and from which point it flows by gravity into the Second Street interceptor and thence into the outfall system. Because of the retention in pump pits and force mains, the sewage is highly septic even before it leaves the main pump station, and the H_2S content considerably above average before it enters the outfall line. A recent survey indicated that the H_2S content at the plant under discussion was 16.1 ppm which was reduced by dilution with other sewage to 10.3 ppm at the disposal plant.

Being a recent incumbent in office I am going to speak only of the condition as I now find it. My attention was very forcibly drawn one morning to the seriousness of the concrete sewers when the superintendent brought into my office a large section of the upper portion of a 22-in. concrete pipe. This section of pipe was found in a manhole on Orange Ave. and we have not as yet been able to determine the exact location from which it came, although it is only reasonable to assume that it had fallen from the arch of the line some 75 ft. south of the man-



Condition of the Interior of the Long Beach Sewer at 7th St. and Orange Ave.

hole from which it was removed. A failure had occurred at this point some time previously, and a temporary repair was made. The finding of this piece of pipe was deemed of sufficient importance to warrant an immediate survey, which survey disclosed a very serious condition.

As previously mentioned, the outfall sewers are constructed of cement pipe exclusively, and vary in diameter from 18 to 48 in. The interceptor particularly referred to, is located on Second St., Third St., Temple, Junipero and Orange Ave, and on Anaheim St. From the entrance of the force main at the extreme south-easterly end of the line to the main trunk on Anaheim St. (14,860 ft.) the pipes are absolutely beyond repair. Plans have been prepared for replacing the present installation with vitrified clay, and already one section embracing some 3,500 ft. has been completed. The outfall system of the City of Long Beach, of which the foregoing is a part, was constructed in 1917.

In designing the outfall system, as in the design of the Belmont Shore sewers, the engineer was probably faced with uncertainty of sewage flow; furthermore, vitrified clay pipe in large sizes was not available in the quality and strength demanded by such an installation. To have constructed brick sewers with cement joints would not have improved the situation to any appreciable degree.

It is most important that sanitary engineers and those who are responsible for the design of sewers know something of the chemistry of sewage. Because the disposal is by dilution and not by treatment at a sewage plant is no reason why the study of chemistry should not be continued. The chemistry of sewage has been well investigated by those in charge of the operation, treatment and disposal at sewage plants, but in many cases it has been neglected so far as the use of suitable materials for the construction of pipe lines is concerned.

The organic solids in domestic sewage are of a character which cause them to become septic in a comparatively short time after entering the sewers, depending upon many factors which will be discussed later. This septization gives off objectionable gases attended by bacteriological action which renders the sewage harmful if allowed to escape from the pipe system, and to contaminate water supplies, bathing beaches, etc. As rapidly as sulphuric acid is produced by bacteria working in and on the concrete, or by atmospheric oxidation, it reacts with the calcium compounds forming calcium sulphate or gypsum. This takes up the water of crystalization, expansion takes place and disintegration becomes both chemical and mechanical, causing sloughing.

The gradients of the Long Beach sewers are flat, .002, with low velocities, averaging 1.5 ft. per second in many places, and the area under discussion, receives a large amount of its sewage from pumping. This sewage is retained in pump wells and force mains for periods varying from a few minutes to several hours before being moved, and the turbulence due to pumping, added to the age of the sewage, tends to hasten its septization. Furthermore, before entering the lines now so badly disintegrated, the sewage must pass through two pumping stations with at least two periods of retention.

No ventilation is provided in the Long Beach sewers as they now exist. The want of such is another contributing cause for the excess of H_2S. There are no automatic or other flush tanks in operation at the present time. Laterals with dead ends and flat gradients permit an accumulation of stale sewage which assists in rapid septization.

The next accentuating factor in the rapid septization of the sewage is temperature. On Aug. 20, 1935, the following temperatures were observed at the locations noted:

LOCATION	Time	Temp. F.	H_2S ppm
Belmont Pump Station	11:15 a.m.	78°	16.01
Second St. and Temple Ave	11:35 "	78°	12.30
Third St. and Junipero Ave	11:50 "	78°	13.02
Third St. and Orange Ave	12:00 m.	79°	13.96
Seventh St. and Orange Ave	12:10 p.m.	79°	13.90
Anaheim St. and Orange Ave	12:20 "	83°	11.14
Anaheim St. and Daisy Ave	12:35 "	82°	9.88
	Outside temperature	75°	

The water supply of the City of Long Beach is obtained from several deep wells and from a chemical analysis the sulphates average as follows:

Calcium Sulphate Trace
Magnesium Sulphate From 0.03 to 1.5 ppm
Sodium Sulphate From 10.1 to 18.6 ppm

From samples of dark sludge taken from the upper portion of some of our sewers, the percentage of free sulphuric acid was found to run from 0.343% to 0.93%.

REMEDIES

Some of the concrete sewers are in such an advanced state of disintegration as to be beyond repair and are being replaced as rapidly as possible with vitrified clay pipe.

Flush tanks will be installed as funds become available, at all dead end laterals.

Ventilation should be provided but this is a difficult problem because of the objection of residents. The sewers pass through well built up districts and in highly developed residential sections of the city.

To save the balance of the interceptors from Anaheim to the outfall, chlorinators will be installed.

Hydrogen sulphide gas can be controlled by the application of chlorine, and it is proposed to install three chorinators. If complete replacement of faulty lines is accomplished, only two chlorinators will be installed, one to be located at the easterly end of the outfall and the other on Anaheim St. at or near its intersection with Orange Ave. By such installation it is hoped that the life of the remainder of the concrete sewers may be extended. The amount of chlorine to be used will be determined largely by experiment, but to commence it is proposed to use from 2 to 2.5 ppm of chlorine to neutralize 1 ppm H_2S. This quantity may be adjusted after analyses have been made and as occasion demands, such as during cooler weather and during the rainy season.

We may experiment, also, with chlorinated iron made by passing the chlorinator discharge continuously upwards through a cylinder filled with scrap iron or old tin cans to produce ferrous chloride. This proposal is expected to be more economical. With the chlorinated iron the volatile sulphide would be fixed as ferrous sulphide. This treatment is described in the July, 1935 issue of the **Water Works and Sewerage.**

The author of this paper has under serious consideration the use of metallic lead coating for concrete sewer pipes, conduits and pump wells. Lead is immune to the attacks of sulphuric acid. The metallic lead is sprayed on, creating an impervious, acid resisting surface.

The concrete walls and ceilings in some of our pump wells are in almost as bad condition as the sewers, and it is proposed to repair such existing wells by cleaning off the affected concrete and lining the walls with vitrified brick set in sulphur silica cement. The decks or roofs of such wells will be covered with laminated 2 x 6-in. fir creosoted with 8# empty cell treatment. Iron ladders will be replaced with hardwood, also creosoted, and framed without nails.

When sulphur cements are used particular attention must be given to the kind and how used. Sulphur cements as such, are highly resistant to acids and other corrosive solutions. The chemical resistance of the sulphur silica mixture is changed, however, when in direct contact with concrete.

In the writer's opinion, concrete pipes or conduits, regardless of the strength or the method of manufacture, will fail if in contact with hydrogen sulphide when oxydized.

Where clay liners are placed in concrete sewers, the following precautions should be taken:

(1) Select only a sulphur cement that has been tested.

(2) See that the clay liners have an edge that will provide a good bond.

(3) Place asphalt between the liners and the concrete.

(4) Have the work supervised only by engineers who have had experience in this class of work.

(5) Failures have occurred where sulphur cement is in contact with concrete. The coating of concrete with sulphur cement has not been successful.

DEMONSTRATION OF A NEW TEST FOR SULFIDES

By RICHARD POMEROY

"The test which I am going to demonstrate was suggested by Emil Fischer about forty years ago as a qualitative test for sulfides. I have found that by certain modifications it can be used for a quantitative method.

"The method in general use at the present time depends upon the addition to the sample of a solution containing antimony, whereby any sulfides present cause a precipitate of orange-colored antimony sulfide. Certain inherent difficulties in this procedure prevent the antimony method from giving results which are more than approximate.

"In contrast to the antimony method, the procedure which I will demonstrate gives results as accurate and reliable as any colorimetric method. Moreover, it gives colors which can be easily estimated at sulfide concentrations of 0.1 ppm, and by slight modifications it can be used for concentrations as low as 0.01 ppm.

"For many purposes the antimony method is accurate and sensitive enough. But if the greater accuracy and sensitivity of this method is available with practically no more trouble, then the more accurate method may as well be used.

"The test shows the total sulfides in the sample, just as do all other simple methods of testing for sulfides."

At this point the method was demonstrated. To 7.4 cc of sample containing about 5 ppm of sulfides there were added ½ cc of a solution of para-amino-dimethyl-aniline in sulfuric acid, and 2 drops of ferric chloride solution. A deep blue developed at once. After one minute, 2 cc of a di-ammonium phosphate solution were added to stabilize the color.

A more complete description of the method will be available in the near future.

THE RELATION OF INDUSTRIAL WASTES TO THE SEWAGE LOAD AT STOCKTON, CALIFORNIA

By WILLIAM T. INGRAM*

The importance of industrial wastes with respect to the domestic sewage load is quite often unthought of or minimized. It is only in recent years that a basis for expressing the harmful effects of industrial sewage in terms of human equivalent has been developed. I should like to present a problem brought about by the rapid industrial development at Stockton.

San Joaquin County was at one time a large grain producing county. In consequence, Stockton industries catered to that product. Since 1920 there has been a noticeable change from grain to fruit and vegetable products, and the canning industry has become a factor in the life of Stockton.

In 1925 the city passed bonds for the development of a ship channel. In 1930 the Stockton Port District was formed to undertake the task of making Stockton an ocean terminal. This was accomplished in February, 1933. Since the first boat docked at the Port of Stockton, growth has been rapid. The original terminal facilities were expanded as quickly as funds would allow.

Two types of industry have been attracted to Stockton. One located here because of the publicity, while the other has come due to economic factors involved in the use of the port facilities and proximity to raw materials.

Prior to 1930 there were two large canneries operating on full-time schedule and other smaller ones working intermittently. During the 1935 season five large canneries, one paper manufacturing plant, one brewery and a milk condensary have been operating on full production basis. In all, it has been estimated that more than a million dollars has been invested in industrial development during the past year and that labor demand has increased about 1500 men. Prospects for future development indicate further increases along the same lines.

The population of Stockton increased from 14,424 in 1890 to an estimated 51,000 in 1935. Future population estimates indicate a 15 per cent increase in 10 years.

Stockton sewerage dates from 1893. At that time the population was 15,000. The disposal plant was located on Mormon Channel in the southwest portion of the city. Sewage was collected in a sump and pumped westerly to the San Joaquin River. The pipe line soon went out of commission and all sewage flowed into Mormon Channel. Foul conditions became unbearable after the diverting canal was built to the north of Stockton. There was no longer a winter scouring action in the channel. Nineteen thirteen marked the beginning of a long period of correspondence between consulting engineers and the city which re-

* Sanitary Engineer San Joaquin Local Health District.

sulted in the adoption of a comprehensive plan of sewer extension and sewage disposal facilities.

By 1919 the outfall lines were completed to the north and south disposal sites. A mechanical screen was installed at the north plant, and the sewage was conveyed from the plant to a point on the San Joaquin River about three miles west of the city. The south plant was constructed and placed in service by 1922. After passing through Imhoff tanks the sewage was discharged to the San Joaquin River just south of the Santa Fe Railroad bridge.

Chlorination was practiced at both plants until 1923 and then discontinued.

From then until the present there has been only one change in sewage disposal. Alignment of the ship channel forced a relocation of the north outfall to secure discharge directly to the channel.

The south disposal plant consists of two Imhoff tanks with an aggregate settling chamber capactiy of 550 cu. ft. and a sludge digestion capacity of about 40,000 cu. ft. It is probable that the tanks were designed for a detention period of one hour on a basis of 1.0 m.g. average daily flow and a sludge capacity of 2 cu. ft. per capita. The connected population in 1930 was estimated to be 18,000 with an additional 1,800 unconnected. The average daily flow from 1925 to 1934 has been about 1.3 m.g. The only measure of solids removed has been that of dried sludge, which ranged from 18.6 to 52.8 cu. ft. per m.g.

At the north plant a 144-in. Reinsch-Wurl screen set at a 22 degree pitch has 3/64 x 2-in. slots and has a peripheral speed of 11.8 ft. per minute. The pumping capacity of the plant is probably about 9 m.g.d. The connected population in 1930 was 30,000 with an additional 8,600 unconnected. Screenings are removed to an open dump and allowed to dry. From 1925 to 1934 the flow varied between 2.3 and 2.7 m.g.d. The average for the period is about 2.5 m.g.d. Screenings for the same period range from 14.8 cu. ft./m.g. to 21.4 cu. ft./m.g.

TABLE I — PLANT DATA—STOCKTON SEWAGE DISPOSAL

Date	South Plant		North Plant		Total Flow
	Av. Daily Flow m.g.	Av. Solids c.f./m.g. D.M.	Av. Daily Flow m.g.	Av. Screenings c.f./m.g.	Av. Daily Flow m.g.
1925	1.2	52.8	2.3	21.4	3.5
1926	1.3	42.0	2.4	21.4	3.7
1927	1.4	41.7	2.7	17.0	4.1
1928	1.3	26.7	2.7	Screen being repaired	4.0
1929	1.2	38.4	2.5	14.8	3.7
1930	1.3	18.6	2.5	15.9	3.8
1931	1.3	39.4	2.5	15.5	3.8
1932	1.4	42.0	2.5	15.0	3.9
1933	1.4	30.3	2.6	14.2	4.0
1934	1.3	43.7	2.5	14.8	3.8
Aug. 1935	2.3	43.4	3.5	26.4	5.8

An analysis of the industrial load completed in July, 1935, indicates that with all industries operating to capacity a flow of 1.6 m.g.d. at the north plant and 2.6 m.g.d. at the south plant could be expected.

Approximately 60 gallons per capita per day for the domestic sewage flow has been selected by comparison of water consumption, winter flow, minimum plant flow, and engineer's estimates. On this basis we might expect flows of 1.9 and 1.2 m.g.d. at the north and south plants, respectively. Thus, with a maximum industrial load the flows would be 3.5 and 3.8, respectively. Comparing the theoretical figures with a study of the plants during the month of August, 1935, we find corresponding flows of 3.5 and 2.3 m.g.d. The discrepancy at the south plant can be accounted for, as a cannery estimated to produce 0.9 m.g.d. was not in operation during the month. With comparative agreement between theoretical and actual flows the conclusion may be drawn that with a maximum industrial load 57 per cent of the entire sewage flow is due to industrial waste.

In order to evaluate the organic load on the plants caused by industry, population equivalents* have been estimated. Segregation of the industrial load into types of industry has been shown in the follow-table:

TABLE II—ANALYSIS OF SEWAGE LOAD-1935-STOCKTON

Type of Sewage	North Plant		South Plant	
	Daily Flow g.p.d.	Pop. Equiv.	Daily Flow g.p.d.	Pop. Equiv.
Milk Products	31,000	300	575,000	1,300
Laundries	123,000	1,200	76,000	900
Canneries	1,200,000	97,500	1,900,000	85,000
Breweries	250,000	41,000	——	——
Poultry	——	——	2,600	100
Domestic	1,860,000	31,000	1,200,000	20,000
TOTAL	3,464,000	171,000	3,753,600	107,300

At the south plant (again using the maximum condition) there would be 87,000 population due to industry plus 20,000 normal population or 107,000 population contributory to the plant. At the north plant the corresponding figures are 140,000 plus 31,000 or 171,000 population contributory. This study leads to the conclusion that 82 per cent of the strength of the organic content of Stockton sewage is supplied by industry.

It is desirable to observe the effect of these conditions on the San Joaquin River. The river is fed by streams heading in the Sierra-Nevada, and the flow is seasonal. It may go as low as 500 sec. ft. during the fall months. The area near Stockton is at the head of the river delta so there is very little grade in the river, and, in consequence, the flow is sluggish. The river is subject to tidal action as far upstream as Brandt Bridge and may have reversal of flow as far as French Camp Slough. The tidal change averages about 3 ft. Numerous sloughs and channels tend to increase the total area of tidal circulation.

* Population equivalents selected from Appendix E, Bulletin No. 28, California State Division of Water Resources. For complete compilation, see pages 38 to 40.

An animal reduction plant on French Camp Slough contributes waste equivalent to 1400 people. A large plant manufacturing fibreboard products by a mechanical process is located on MacDougald Canal adjacent Mormon Channel. The plant produces 250 tons of pulp daily, and the entire waste estimated, equivalent to the sewage of 50,000 people, is discharged to the canal.

The State Bureau of Sanitary Engineering made a survey of the river in 1930, and in September, 1935, the Bureau and the Local Health District made another survey. Tests for dissolved oxygen, 5 day B.O.D., B. Coli, pH, alkalinity, chlorides, and examination of microorganisms were made. In 1930 the dissolved oxygen ranged from 120 per cent at Brandt Bridge to 88 per cent at the Empire Tract some miles west of Stockton. B. Coli at Brandt Bridge was 2.5 per cc; at Borden Highway 110 and at Gortons Landing on the channel 11. The alkalinity was within the limits of 28 and 40 ppm., and chlorides varied from 51 to 105 ppm. The chief organisms found were diatoms.

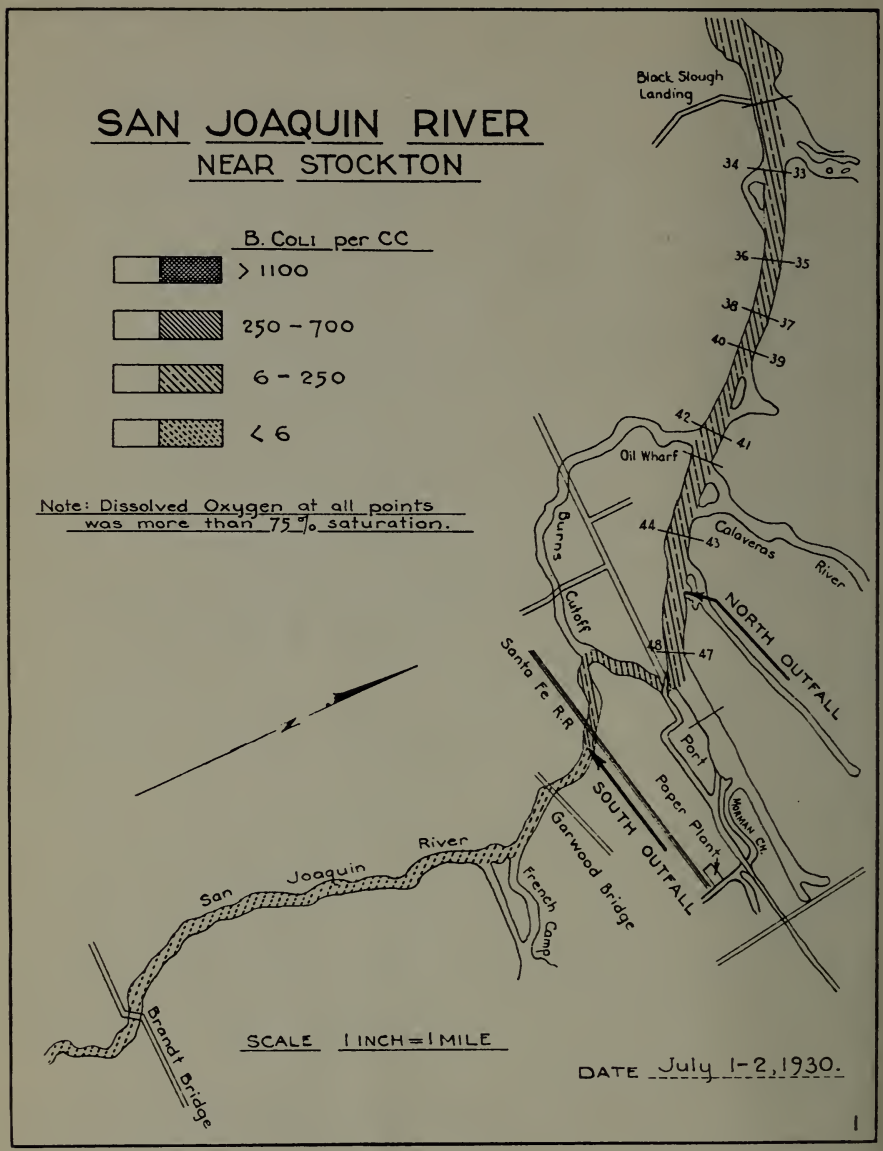
For 1935, a radically different situation exists*. Even under the most favorable condition of a high or incoming tide, over seven miles of the channel have less than 75 per cent dissolved oxygen content. In Mormon Channel, the dissolved oxygen ranges from 50 per cent to septic in the upper reaches. On the outgoing or low tide, conditions were critical. Over five miles in the channel have less than 25 per cent dissolved oxygen. The recovery to 75 per cent dissolved oxygen takes place some seven miles below the port. Septic conditions exist in Mormon Channel almost to its outlet.

The B. Coli content also indicates an alarming contamination even under high tide conditions. From French Camp Slough to Black Slough Landing the water contains more than 6 B. Coli per cc. Heavy contamination exists in the vicinity of each outfall and Mormon Channel. Under low tide conditions there was no portion of the river from Brandt Bridge to Black Slough Landing which did not have B. Coli in excess of 6 per cc. More than 1100 per cc. were found in the area from the south outfall to a point about three miles below the port.

Alkalinity was between 116 and 174 ppm., and chlorides ranged from 74 to 272 ppm. in the main channel. A cold storage plant on Mormon Channel causes chlorides to run up to 700 ppm. Diatoms were the most prevalent organisms; however, a few nematodes and protozoa were present. It may or may not be of significance that rotifera and crustacea are noticeable by their absence.

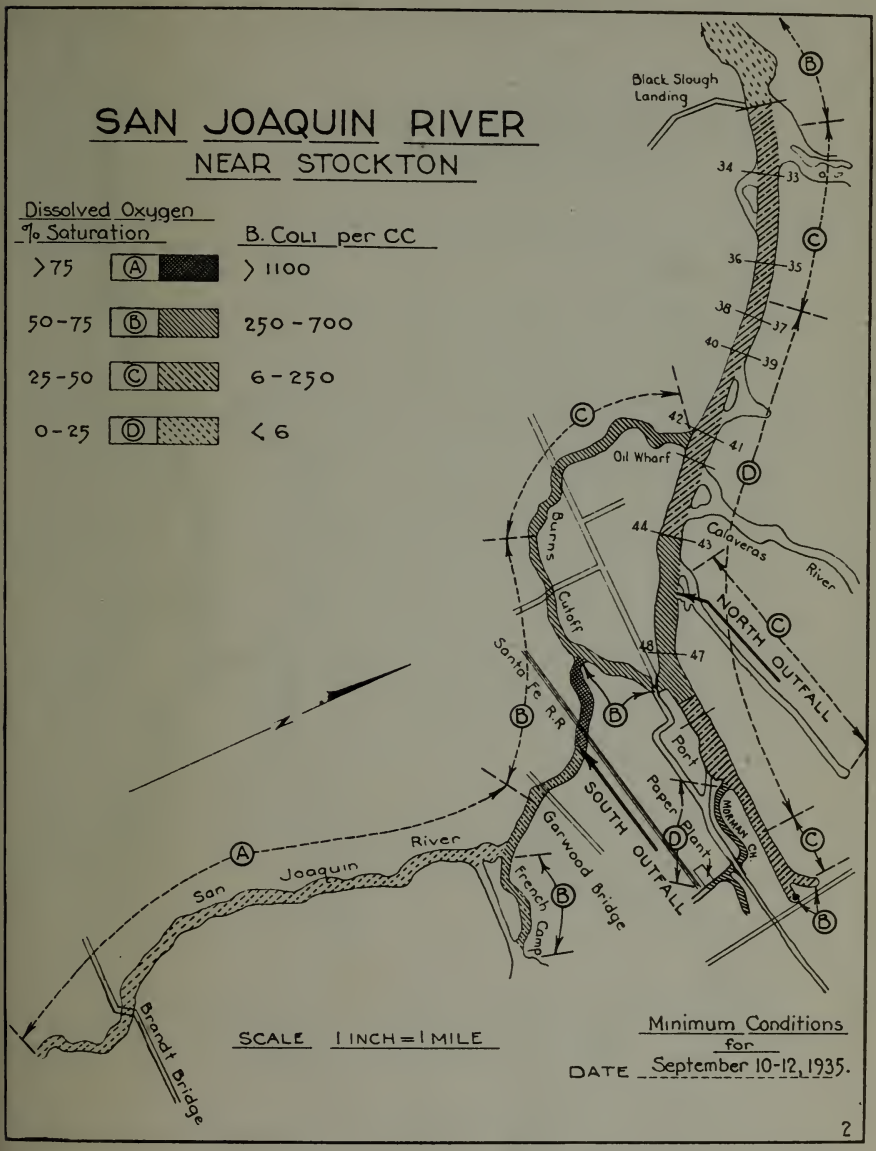
A physical examination of the river also serves as a guide to its condition. Floating debris carried from the sewage plants was observed in the vicinity of Garwood Bridge on the upper side and below the Stockton Country Club on the lower side. The port area is reasonably clean; however, at a point between the north outfall and the port, where a dredger was operating, gas ebullitions were noticed. The muck being removed from the bottom had a noticeable odor and was quite black. The 5 day B.O.D. of the return water from the spoil area was 5 ppm. There is reason to believe that heavy river flows during the winter

* See charts on following pages.



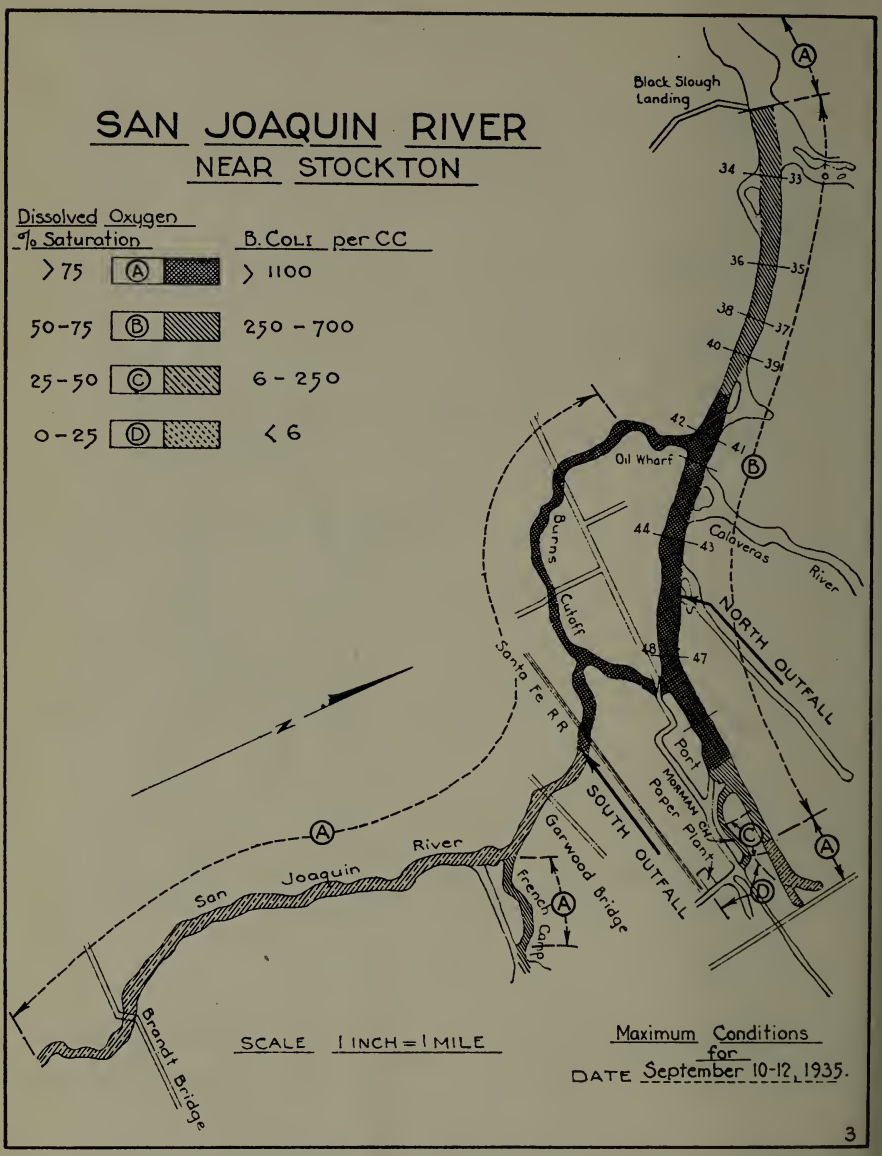
Conditions resulting from discharge of sewage and industrial waste into the San Joaquin River at Stockton.
July 1–2, 1930

(From a survey by the Bureau of Sanitary Engineering)



Minimum conditions of polution resulting from the discharge of sewage and industrial waste into the San Joaquin River at Stockton. Sept. 10–12, 1935

(From a cooperative survey by the Bureau of Sanitary Engineering and the San Joaquin Local Health District)



Maximum conditions of polution resulting from the discharge of sewage and industrial waste into the San Joaquin River at Stockton. Sept. 10–12, 1935

(From a cooperative survey by the Bureau of Sanitary Engineering and the San Joaquin Local Health District)

months may effect a good scouring in the channel and prevent the formation of sludge deposits of any serious proportion.

Mormon Channel is characterized by sludge deposits, floating sludge, gas bubbles, black water and vile odors. Altogether, this condition is abominable and is due almost entirely to industrial pollution.

Over several miles of river numerous fish have been found dead. One cannot say whether this is due to the low oxygen content or other causes.

From the foregoing, it is evident that the industrial waste factor is important.

Briefly reviewing, industrial development may occur suddenly as a result of circumstances unforeseen, thus antiquating sewage disposal plants which would prove adequate under normal conditions.

Excessive flows and organic loads are placed on sewerage and treatment plants, thereby lessening the possibility of satisfactory treatment.

Lowering of plant efficiency causes a correspondingly higher pollution of the diluting stream, and this in turn may create a stage of pollution wherein the stream is overtaxed and the attendant critical conditions of low dissolved oxygen, high bacterial contamination, undesirable appearance and obnoxious odors result. Destruction of fish food and possibly fish life may occur under these conditions.

It has been the purpose of this paper to illustrate the importance of industrial wastes. With regard to Stockton, suffice to say that, due to industrial sewage, a city of 51,000 population has grown to 147,000 on a flow basis and 296,000 on a biochemical oxygen demand basis.

(Acknowledgement is made to the State Bureau of Sanitary Engineering and the City of Stockton for certain data contained in this paper.)

Note: A table of population equivalents of industrial wastes prepared by the Bureau of Sanitary Engineering is presented on the next pages.

SYMPOSIUM ON GAS ENGINE OPERATED WITH SLUDGE GAS

The papers by Tennant, Greeley and Banks are published in the **Sewage Works Journal.**

APPROXIMATE POPULATION EQUIVALENTS OF INDUSTRIAL WASTES

These values are computed from various sources, often based on fragmentary data. Wide variations may be expected.

INDUSTRY	TYPE OF WASTE	Population Equivalent	UNIT OF MEASUREMENT	SOURCE OF INFORMATION
Brewing	----------	15	Barrel of beer	U.S.P.H.S.
Canning	Apricot (with lye peeling)	300	Ton of raw material	Calif. Bull. 28 Dept. of Public Works
	Apricot (without lye peeling)	100	" " " "	" " " "
	Asparagus (excluding butts)	20	" " " "	" " " "
	Asparagus (including butts)	230	" " " "	" " " "
	Beet	30	" " " "	" " " "
	Fig	30	" " " "	" " " "
	Pea (shelled)	200*	" " " "	Waterworks & Sewerage, May, 1931
	Peach	200	" " " "	Calif. Bull. 28
	Pear	130	" " " "	" " "
	Pear (excluding trimmings)	30	" " " "	" " "
	Sardine	20	" " " "	" " "
	Spinach	30	" " " "	" " "
	Tomato	120	" " " "	U.S.P.H.S. Bull. No. 171
	Tomato (excluding trimmings)	200	" " " "	California Bull. 28
	Pork and beans	109	" " pork & beans	Indianapolis
Corn Products	----------	7	Bushel	U.S.P.H.S. Bull. No. 171
	----------	5	"	Jour. A.W.W.A. Vol. 17, Jan. 1927
Distilling	----------	480*	Barrel of whiskey (—10 bushels grain)	U.S.P.H.S. Bull. No. 171
Dried Fruits	Wash water	20	100 gallons waste	California Bull. 28
Flour	General Mill	15	Ton of raw material	" " "
Glue	----------	20	Per employee	U.S.P.H.S. Bull. No. 171
Grease & Oil	----------	1	" "	" " " "
Laundry	----------	24	Per 100 lb. clothing	Indianapolis
Malting	----------	0.1	Bushel of barley	Sewage Wks. Jnl. May, 1935
Meat Products	General slaughterhouse	40	Animal killed	U.S.P.H.S. Bull. No. 171
	Combined waste	20	" "	" " " "
	General Packinghouse	30	" "	" " " "
	Pork packing	20	" "	" " " "
	Hog killing	10	" "	" " " "
	Cattle slaughtering	20	" "	" " " "
	Lard and sausage	10	" "	" " " "
	Poultry killing and cleaning	25	100 head	California Bull. 28

* Estimated from data in original article.

INDUSTRY	TYPE OF WASTE	Population Equivalent	UNIT OF MEASUREMENT	SOURCE OF INFORMATION
Meat Products (Cont'd.)	Fish cutting & cleaning			
	Shad	30	Ton of fish	California Bull. No. 28
	Salmon	60	" " "	" " "
	Catfish	60	" " "	" " "
	Rendering	35	Per employee	U.S.P.H.S. Bull. No. 171
Milk Products	General creamery	35	100 lb. butter fat	" " " "
	" "	20	" " " "	U.S.P.H.S. Bull. No. 109
	" "	50	1000 gal. milk & cream	" " " "
	" "	35	" " " "	California Bull. No. 28
	Bottling plant	38	" " " "	Sewage Wks. Jnl. May, 1934
	Cheese factory	129	" " " "	" " " "
	Condensery	38	" " " "	" " " "
	Receiving Station	22	" " " "	" " " "
	Whole milk	3420	" " " "	California Bull. No. 28
	Skimmed milk	2800	" " skimmed	Iowa St. Coll. Bull. 68
	" " (90% whole)	2550	" " milk	California Bull. 28
	Buttermilk	2600	" " buttermilk	Iowa State Coll.
	" (10% whole)	260	" " milk	California Bull. 28
	Whey	1750	" " whey	U.S.P.H.S. Bull. No. 109
	" (87% skimmed)	1370	" " milk	California Bull. No. 28
Olive Products	Oil pulp liquor	300+	Ton of olives	Calif. Bureau of San. Eng.
Paper Products	Sulphite pulp	13,000	Ton of product	Jour. A.W.W.A., Jan., 1927
	" "	1378-2630	" " "	Paper Trade Jnl., July, 1935
	General Paper Mill	780	" " "	Jour. A.W.W.A.
		28.6-30.8	" " "	Paper Trade Jour.
	Leatherboard	1000	" " "	U.S.P.H.S. Bull. 171
	Straw & paperboard	630	" " "	" " "
	Strawboard	1570	" " "	" " "
	"	2500	" " "	Jour. A.W.W.A.
	Rag felt	200	" " "	California Bull. 28
Soap		15	Per employee	U.S.P.H.S. Bull. No. 171
Sugar	General refinery—cane	20	Ton of raw sugar	California Bull. 28
	Beet—Flume water	17	Ton of beets	Mich. Exp. Sta. Bull. 51
	Battery wash	11	" " "	" " " "
	Pulp Press	19	" " " =	" " " "
	Lime cake drain	4	" " "	" " " "
	Steffens	20	" " "	

INDUSTRY	TYPE OF WASTE	Population Equivalent	UNIT OF MEASUREMENT	SOURCE OF INFORMATION
Tanning	Hide tanning	22	Per hide	Jour. A.W.W.A.
	" "	15	" "	U.S.P.H.S. Bull. 171
	Calfskin tanning	5	" skin	" " "
	Sheepskin "	2*	" dozen skins	" " "
	Harness leather	20	" hide	" " "
Textiles	Wool scouring (grease wool)	30	100 lb. raw material	Jour. A.W.W.A.
	Wool yarn & cloth (scouring)	24*	" " " "	U.S.P.H.S. Bull. 171
	Wool yarn & cloth dyeing	15*	" " " "	" " "
	Wool yarn & cloth dyeing and scouring	124	" " " "	Jour. A.W.W.A.
	Wool & mixed goods, washing & dyeing	45*	" " " "	U.S.P.H.S. Bull. 171
	Cotton yarn & cloth, bleaching	120*	" " " "	" " "
	" " " dyeing	25*	" " " "	" " "
	Cotton yarn & cloth, bleaching & dyeing	115	" " " "	Jour. A.W.W.A.
	Cotton cloth bleaching, dyeing & finishing	15*	" " " "	U.S.P.H.S. Bull. 171
	Silk washing & dyeing	10	1000 gal. waste water	Conn. Dept. Health 1818-21
Wine Making	Dry wine	40	Ton of grapes	C.S.W.A. Jnl. Vol. VII, No. 1
	Sweet wine	130	" " "	" " " "
	Still slops	225	" " "	Calif. Wine Review, Nov. '34.
	Lees	35	" " "	" " " "
Domestic Sewage		1	Per person	U.S.P.H.S. Bull. 171

* = estimated from data in original article.

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Discussion by Mr. Ingram:

There are two schools of thought with regard to the imposition of industrial loads and how to cope with them. One idea is that each industry be made to treat or pretreat in a manner suitable to the city officials. The other is that the city accepts the full responsibility of treatment and must prepare for it accordingly.

In view of the trend in the east, where experiments are being tried, to dispose of garbage by grinding it and combining it with other sewage, it is quite possible that the bases of sewage treatment design for industrial areas will have to undergo considerable change. This same situation also involves the sewerage system.

It may be possible to develop plants on a unit basis which could be cut in when canneries and other industries required additional treatment facilities, or the plant could have auxiliary chemical treatment to be used on heavy industrial loads. I believe Professor Hyde is impressed with the possibilities of modern chemical treatment.

GAS ENGINES FOR THE SEWAGE DISPOSAL PLANT

By A. K. HEGEMAN*

The increasing use of the gas produced by the digestion of sewage as a source of fuel for internal combustion engines adds but one additional type of fuel to the many others which are already being utilized to operate such equipment. In various industries, gas engines are being operated on blast furnace gas produced in the steel mills; on producer gas manufactured by the partial combustion of coal; on oil gas obtained from similar partial combustion of petroleum; on natural gas obtained from nature's reservoirs, some of it being produced in association with petroleum, some from reservoirs, remote from such petroleum deposits; on tank vapors which under atmospheric temperature boil off the crude oil storage tanks in the oilfields; on still vapors driven off petroleum in the refineries during refining processes; on marsh gas; and even, in some remote sections, on charcoal gas obtained from charcoal.

It is only natural that gas engine manufacturers have been forced to investigate the chemical, physical and thermal characteristics of the various gases as well as their behavior under combustion in enclosed spaces, and to adopt their engines to the utilization of such fuels. That this was not a simple problem can be recognized when it is realized that some of the gases mentioned above have heat values as low as 135 B.t.u. per cu. ft.; others, as high as 3000 B.t.u. per cu. ft. In comparatively recent years, it was definitely determined that the most important feature in connection with the behavior of a gas under combustion in an engine is the speed with which it burns; in other words, the rate of flame propagation as the flame travels away from the point of ignition. This information having been determined, it was comparatively simple to ascertain that the compression ratio of the engine must be varied according to the rate of flame propagation of the fuel, this because high compression hastens that rate. It was also determined that thermal efficiency varies directly with the compression ratio. Therefore, from an efficiency standpoint, it is well to have as high a compression ratio as possible. However, there are limits to which this rule can be carried. The higher the compression, the higher the temperature of the unburned gas before ignition. The higher this temperature, the more rapid the burning of the fuel, and too rapid burning results in an ignition knock which is damaging to the engine bearings. Manufacturers met this problem by so designing the combustion chambers as to present as much cooling surface as possible to the compressed fuel, thereby decreasing the initial temperature caused by compression and thereby making high compression ratios possible without detonation. It is apparent that for a given gas there is no fixed rule by which to deter-

* Sales Engineer, Smith-Booth-Usher Co., Los Angeles.

mine a standard compression ratio for different engines. Some variation must be expected as the result of differences in combustion chamber cooling.

Maufactured gas usually contains methane, carbon monoxide, and hydrogen as power producing constituents mixed with high percentages of nitrogen and other inerts. California natural gas ordinarily contains over 90% methane with fractional percentages of oxygen, carbon monoxide, carbon dioxide and hydro-carbons other than methane. Sewage, or sludge gas appears to consist almost entirely of methane and carbon dioxide with small percentages of nitrogen and hydrogen sulphide. The usual presence of over 30% carbon dioxide in this type of gas makes it, compared to natural gas, a comparatively slow burning fuel. The engine manufacturer who is familiar with such matters therefore builds an engine which is to operate on sludge gas with a higher compression ratio than would be the one case were the fuel to be natural gas, the exact ratio being dependent upon the analysis of the gas.

Hydrogen sulphide is very undesirable and is unfortunately, often present in sludge gas. It has two effects:

1. Upon the potential compression ratio.
2. Upon the metallic parts of the engine.

Hydrogen sulphide, upon ignition, tends to detonate and therefore if more than ½ of 1% is present, may make it necessary to decrease the compression ratio.

It unites with the water which is formed by combustion of the hydrogen in the fuel and forms acids which corrode the valves, seats, cylinders, pistons, and exhaust piping. Such corrosion can partially be overcome by judicious use of corrosion resisting alloys in the construction of an engine and it is therefore apparent that some engines might safely burn a fuel having a high sulphur content which might severely damage another engine. No general figure for the maximum allowable amount of sulphur can be stated.

Investigation among chemists of several responsible lubricating oil refiners leads to the conclusion that until the acid concentration in the crankcase becomes very high, sulphur has no effect upon the oil. The lubrication ills often attributed to sulphurous fuel are in all probability (particularly in diesel engines) due to a combination of poor lubricating oil and dirty fuel. It would probably be in order to drain the crankcase of engines using sulphurous fuel more often than would be necessary with non-sulphurous fuel. It would also be advisable to avoid cooling the exhaust near the engine, thereby avoiding condensation of acid in the manifolding.

TYPES OF ENGINES AVAILABLE

Engines available as prime movers in sewage plants are of both the horizontal and vertical types. The crosshead type horizontal engine has no superior as a long lived, low maintenance cost unit. The writer has knowledge of engines of this type which have operated here in California twenty four hours per day for over twenty-five years and are

still operating with less than 1% loss of time for repairs. This type of engine generally operates at less than 300 r.p.m. and therefore must usually be connected to the driven apparatus by some increasing unit such as a gear or belt. Well engineered belts and gears are not a source of mechanical difficulties, nor of high maintenance expense. As a general rule, horizontal crosshead type engines in which the crosshead eliminates all side thrust on the cylinder walls, except the insignificant pressure caused by the weight of the piston, show a higher first cost but lower maintenance expense than the vertical engine. Trunk piston, or non-crosshead type horizontal engines, are built to sell at comparaticely low prices but are to be avoided on account of high maintenance costs. Four cycle engines of this type operate at from twenty-two to twenty-six per cent thermal efficiency. Two cycle horizontal engines with the fuel injected under slight pressure after completion of the scavenging action, are simpler in construction than the four cycle type, show lower maintenance costs, and operate at from twenty-five to twenty-nine percent thermal efficiency. For generation of electric power horizontal engines are not generally as satisfactory as are vertical engines.

VERTICAL ENGINES

Most of the vertical engines are of the four cycle type, although a few two cycle units well worthy of considerable thought have been developed. This type may be sub-divided into several classes:

1. Large, heavy, low r.p.m. units,
2. Medium sized, moderate weight and r.p.m. units,
3. Small, light, high speed units.

The first of these classes consists of engines of over 12 in. stroke. As a rule they are very heavily constructed, weights as high as two hundred pounds per rated horsepower being common. The parts are so heavy as to create high inertia forces and as a result piston speeds seldom exceed 700 ft. per min. Higher speeds result in bearing difficulties and are to be avoided. Ratings are usually on the basis of from 65 to 70 lb. per sq. in. brake m.e.p. Overloads causing higher brake m.e.p. result in overheating, detonation, rapid cylinder and piston ring wear, burned out valves, back-firing, etc. and are to be avoided. Only the very largest sewage treatment projects could make use of this type of engine.

The second classification covers that type of engine which has been developed during the past ten years, embodies all of the latest features made possible by recent metallurgical discoveries and will probably prove most useful in sewage treatment plants. By taking advantage of comparatively recently developed high strength low weight alloys, designers have been able to build this type of engine to operate at piston speeds as high as 1000 ft. per min. while keeping the weight down to between sixty and ninety pounds per rated horsepower. Higher piston speeds will be possible as still lighter and stronger metals capable of withstanding higher stresses due to inertia are developed. Ratings are usually on the basis of from 65 to 70 lbs. per sq. in. brake m.e.p.

and higher ratings are to be avoided for reasons already stated. Strokes range from eight to twelve in. Inasmuch as several manufacturers build this type of engine on a production basis, whereas the larger engines included under the first classification are seldom constructed on such a basis, the price of repair parts per unit of power is lower than for the larger engines. Moreover, the parts are lighter and more easily installed. This type of engine does not, like the heavier engine, require overhead cranes for pulling heads and pistons. A light chain block suspended from a roof truss is adequate.

The third, or high speed class of engine, can be used to considerable advantage in small sewage plants, as well as for auxiliary drives in large plants. While often referred to as "the automotive type" of engine, this type should not be confused with those engines which are used in the modern pleasure automobile. Engines used in such automobiles operate at entirely too high speed for continuous heavy duty. Moreover, they usually develop peak torque at such high speed that operation at a reasonable piston speed can be accomplished only by operation below the speed at which the torque curve peaks. When so operated, the slightest mishap such as a miss or a sudden increase of load, is apt to kill the engine.

Selection of this type of engine should be confined to those models which are manufactured for severe service in trucks, tractors, heavy construction equipment, etc. Literature published by manufacturers of this type of engine usually show developed horsepower curves and S.A.E. or I.C.E.I. ratings. Almost invariably these curves and ratings indicate the horsepower momentarily developed on test by an engine having no fan, generator, water pump or other accessories and should be disregarded by the engineer who is selecting an engine for stationary and continuous service. The engine should be selected upon the basis of 65 to 68 lbs. per sq. in. brake m.e.p. and a reasonable piston speed. For units of from 5 in. to 8 in. stroke, 1000 ft. per min. is a reasonable piston speed. For shorter stroke units, 1150 ft. per min. for four cylinder and 1300 ft. per min. for six cylinder units is permissible.

BRAKE MEAN EFFECTIVE PRESSURE

This can be determined from the formula:

$$P = \frac{\text{bhp. x } 33{,}000}{L\ A\ N} \text{ where}$$

P=brake mean effective pressure in lbs. per sq. in.
bhp.=brake horsepower per cylinder
L=length of stroke in ft.
A=piston area in sq. in.
N=number of power strokes per min.
For a four cycle engine N=r.p.m./2
For a two cycle engine N=r.p.m.

MAINTENANCE AND OPERATING COST

The question often is asked, "How long will an engine last in my plant?" A fair and honest reply is, "A lifetime with intelligent and conscientous care; six months without."

A gas engine, unlike an electric light globe, does not serve its alloted span and then suddenly collapse. Deterioration of an engine is a very gradual process which can be halted at any time by the application of a bit of intelligence and initiative. Accidents which completely wreck a unit are exceedingly rare and if not caused by some hidden defect in material, are usually caused by failure on the part of the operator to care for the equipment in a suitable manner or by his failure to observe ordinary rules of good conduct when dealing with machinery. Don't lubricate with the cheapest obtainable oil, don't expect spark plugs to last forever, don't overload an engine over 70 lb. brake m.e.p., don't put off grinding those valves, changing those piston rings, eliminating that bearing knock, checking that valve and ignition timing, and the engine may be counted upon to show an involutary shut-down record of less than 0.5% for many years. Reasonable depreciation periods are fifteen years for low and moderate speed engines, five years for higher speed engines.

Many an engineer has avoided installing an engine in his plant on account of fear of high maintenance costs. At the present time a 200 h.p. engine is being operated in a sewage plant in California under a contract by which the owners are guaranteed complete maintenance including parts and labor over a period of five years at the rate of $2.63 per h.p. per year. In a paper read before the California Natural Gasoline Association at its August, 1935 meeting at Los Angeles, a paper which will be published in the October, 1935 issue of the "Petroleum World," Mr. J. C. Burks, Superintendent of the O. C. Field Gasoline Co. of Los Angeles, discussed various costs connected with the operation by his organization of one engine belonging in Class 2 and seven engines belonging in Class 3. He shows an average lubrication cost of .396 mils per h.p. per hr. and an average engine repair cost of 0.363 mils per h.p. per hr. These figures are respectively equivalent to $3.47 and $3.18 h.p. per year, higher in the latter case than the guaranteed cost under the contract described above. However, it must be understood that the figures apply to different classes of engines and that the lighter, less expensive higher speed engines covered by Mr. Burks' report may be expected to show a higher maintenance cost.

An engineer for one of California's largest oil companies, reporting on a 1,050 r.p.m. 5½ x 6½ four cylinder engine which had been operated for over 33,000 hours by his company, shows a maintenance cost to date of $3.30 per h.p. per year and concludes his report with the words, "From every indication, the engine is as good as new."

GENERAL

Those who are unfamiliar with gas engines are often inclined, as a result of their inexperience, to prepare specifications which are so wide

open that cheap engines which are absolutely unsuitable for continuous service, may be offered under those specifications. The engineer who is designing a plant which will be of such size as not to warrant the employment of a crew of highly skilled gas engine operators, should select equipment which is as simple in design as is compatable with good performance. Engines of the moderate and high speed types are generally built on production basis and are easier and less costly to repair than engines of the heavy slow speed type. Ell head engines have far fewer working parts and less minute adjustments than do the overhead valve engines. As a rule the heads and combustion chambers are better cooled than those of the overhead valve design. The heavy side thrust which makes cylinder liners absolutely essential in trunk type piston diesel engines is non-existent in gas engines. Such liners are therefore unnecessary and are often the cause of maintenance difficulty.

Limitation of space in rail locomotives, submarines and automobiles has led to the development of the "V" engine. This type of engine is difficult to lubricate and repair, is subject to rapid cylinder wear, has complicated timing adjustments and is unsuitable for stationary plant service unless a highly skilled crew is in attendance.

Inexperienced engineers often are led to believe that a successful builder of diesel engines or of speed boat or automobile motors can at will turn out a good gas engine. Such is seldom the case. The manufacturer of stationary gas engines must have had considerable experience with this type of fuel before his engines can be counted as entirely dependable. Highly competitive conditions exist in this industry and the purchaser does not, in self-defence, need to admit inexperienced manufacturers to the competition for his business.

LUBRICATION AND COOLING

Forced feed lubrication of engine bearings is so far superior to splash or flood lubrication as to deserve mention in specifications. Lubrication through rifled connecting rods and crankshafts eliminates the possibility of broken oil lines and should be specified. Lubrication systems should include oil filters and protective controls to stop engines in case of oil failure.

Lubricating oil should be selected with as much care as the engine itself and should be purchased as the result of submitted specifications, not because of widespread advertising campaigns. High flash point low carbon content oils are essential to good operation and long life. Various types and makes of engines vary greatly in the amount of oil consumed. Records as low as 700 and as high as 6600 h.p. hrs. per gal. are available. For slow or moderate speed engines, 3,000 h.p. hrs. per gal. is an average figure.

Scale is deadly to gas engines and therefore soft water should be used for cooling. Safety stops to stop the engine in case of water failure should be provided.

THERMAL EFFICIENCY

For estimating purposes 20% thermal efficiency is a safe figure. In making calculations, the net heat value of the fuel as described by W. B. Walraven in an article in the **May, 1933** issue of **Water Works and Sewage,** may be used.

UTILIZATION OF WASTE HEAT

Between 60% and 70% of the total heat of combustion passes off the engine in the cooling water and exhaust gases. In sewage plants at least 90% of this heat can be utilized for digestion heating and other purposes. If the engine is already converting 25% of the heat to power, the amount of recoverable heat therefore amounts to between 65% and 75% of the total. Such potential efficient use of a by-product gas which has up to this time often been discarded as useless makes the gas engine an exceedingly valuable piece of equipment to the sewage plant designer. It is to be hoped that the success which has so far been experienced by those who have installed such engines, will be noted and the example of the pioneers followed by the other members of that profession.



The 200 h.p. engine operating on sludge gas at the joint disposal plant of the Los Angeles County Sanitation Districts.

WHY THE GAS ENGINE AT THE ONTARIO SEWAGE DISPOSAL PLANT?

By AUSTIN BURT*

Up to the present time the City of Ontario has utilized the sewer farm method for the disposal of sewage from its own sewer system as well as the sewage from the adjoining City of Upland.

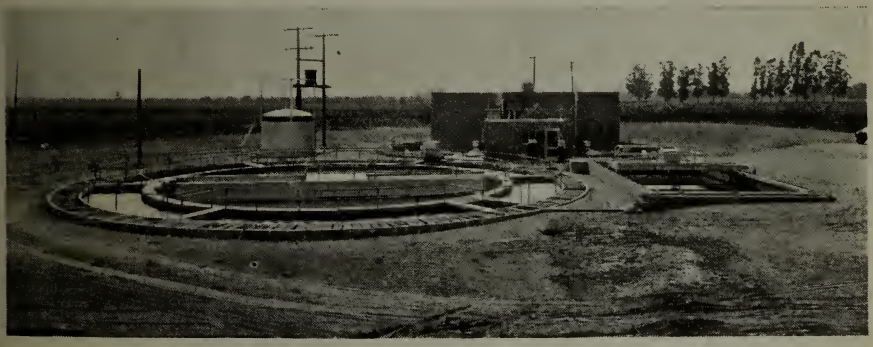
The combined population of the two cities is close to 20,000 whereas the actual population served by the sewer systems of both cities is about 60% or 12,000.

A little over a year ago compliance with the regulations of the State Board of Health made it imperative to discontinue the use of the sewer farm and provide for a modern sewage disposal plant. At that time P. W. A. funds were still available altho it was intimated that the limit was about reached and haste would be necessary in making application. The services of Currie Engineering Co. were secured to make the necessary survey and prepare plans and specifications for an activated sludge disposal plant.

Although crowded to the limit for time, Mr. Currie submitted a new and rather unique design for consideration. After making sure that no unnecessary chances were being taken the new design received the approval of the P.W.A. officials and the City Council. Preliminary estimates indicated a cost for an adequate disposal plant of about $110,000. The proposed Currie Plant called for a total cost of only $80,000.

The outstanding features of this Currie design are the use of circular tanks for everything except the primary clarifier.

The secondary clarifier and digester tanks, each 50 ft. in diameter, are surrounded by outer tanks like moats 80 ft. in diameter. These



The Ontario Sewage Treatment Plant. Note annular type of construction.

* City Engineer, Ontario, California.

annular tanks, about 11 ft. wide, provide for the aeration, re-aeration tanks and space for laboratory and power plant. Each of the annular tanks is divided into six sections by radial walls with retention openings. Four of the clarifier sections and five of the digester sections are used for aeration and the other two clarifier sections are for re-aeration while the sixth digester section is used for the power equipment with the laboratory and control room in a pent house above it.

The primary clarifier is rectangular, 20x45x9.5 ft. deep and discharges through a Venturi flume into a channel-way around the upper inside edge of the outer wall of the aeration tanks. From this channel-way the sewage can be delivered into any of the aeration or re-aeration sections.

This design of circular and annular tanks, together with other special features of construction, it is claimed by the designers, has resulted in the lowest construction cost of any disposal plant in the United States.

The large saving thus made in first cost, especially commendable under the stress of present conditions, of course should not be made the subject of the slightest criticism, never-the-less it does frequently happen that careful consideration is not always given to the Kelvin balance between investment and operating cost. It was a study of this phase of design that led to the substitution of the gas engine for one of three electric motors for driving the Roots-Connersville blowers.

There appeared to be very little experience here on the Coast to encourage one to use a gas engine operating with sludge gas. An engine installed and operated by Mr. W. B. Walraven at Springfield, Ill., (Sewage Works Journal, July, 1932) appeared promising. Advantage was taken of a vacation visit of Mr. Jack Gordon, our fire chief, to Indiana to have him go to Springfield and get first hand information. His report was so enthusiastic as to its successful operation and the substantial saving made in operating costs that we felt that no chances were being taken in substituting this kind of a unit.

At first it was thought that a low price, high speed engine for stand-by purposes only would be best but more extended study revealed that the most profitable unit would be a slow-speed, direct connected, industrial engine.

In order to limit the field of choice the specifications were very carefully drawn requiring among other things a maximum of 55 lbs. brake m.e.p. at full load and speed of 600 r.p.m. This resulted in the purchase of an Enterprise Engine, made in San Francisco. It is a 4 cylinder engine with 6½ in. bore 8½ stroke with removable cylinder sleeves and must operate successfully on sludge gas of approximately 600 B.t.u. with a speed variation of not to exceed 4% above or below normal for any setting of the governor between 600 r.p.m. and 300 r.p.m.

The plant was placed in operation about two months ago and it was not until three days ago that the gas was sufficiently strong to permit full operation of the engine. Preliminary tests were made with natural gas of 1,100 B.t.u. value and the performance was fully satisfactory. Carburetor trouble developed in changing over to sludge gas. This was effectively remedied by the use of the new Power-Plus carburetor, de-

signed and made by Mr. George S. Maslen, Los Angeles. The ease of making the air ratio adjustment is the outstanding feature of this appliance.

It is rather difficult to draw any satisfactory conclusions from the operation of an engine that has run part time only for 3 days on sludge gas that is less than a month old. Fortunately by showing the annual saving to be secured through the use of a single 12 in. Venturi tube, equipped with a Maurey-Jones air flow meter, in place of three 8 in. orifice meters with manometers we are equipped to make reasonably accurate measurements of air flow and hence brake horsepower on the engine.

In a test made at full speed of 600 r.p.m., 4.6 lb. at the blower, 85 deg. inlet and 158 deg. F. outlet and a delivery of 1,460 cu. ft. of free air the engine consumed 890 cu. ft. of sludge gas per hr. Calculation showed about 30 b.h.p. and a little less than 30 cu. ft. per b.h.p.-hr. With natural gas of 1,100 B.t.u. heating value this would not have been over 12 cu. ft. and with sludge gas of 650 B.t.u. it should not have been more than 22 cu. ft. This would indicate that the sludge gas was still diluted to about 400 B.t.u. value.

For the purpose of estimating the approximate equivalent cash value of the sludge gas as compared with electric power recourse has been had to a formula derived by Mr. Walraven in his article just referred to.

Slightly modified it is stated as follows:

For electric power,

To find the annual value of sludge gas for power purposes multiply the average daily flow of sewage gas in cu. ft. by 17 times the price of electricity in dollars per kw.hr.

For other commercial gas,
Multiply the average daily flow of sewage gas in thousands of cu. ft. by 200 times the price of the other gas in dollars per million cu. ft.

With a flow of 7,000 cu. ft. per day and electric rate of $.01 the annual value of our sludge gas would be $1190. or $.47 per million cu. ft.

This annual value does not account for capital charges and depreciation, so the difference between these charges for sludge gas engine and electric motor must be deducted to get the true annual value.

Taking a difference of $28 per h.p. installed in favor of electric drive and 12% interest and depreciation the above annual value will be reduced by $150 or a net of $1040. Capitalized on a 20 year basis this indicates that an investment in sludge gas engine equipment of $5,200 could be made to balance electric drive. The actual investment was $1,865.00 thus affording reasonable assurance that no mistake was made in the installation of the gas engine.

DISCUSSION

Mr. Anaya: "I would like to ask the first speaker (Mr. Tennant) whether they have electric standby."

Mr. Tennant: "No. We have no auxiliary equipment for the engine."

Mr. Anaya: "Do you have any control over the B.t.u. of the gas? From what has been said I gather that this may vary from 400 to 700 B.t.u. per cu. ft."

Mr. Tennant: "That is a detail not overcome. Gas from the same tank will vary from day to day. Why, I don't know."

Mr. Anaya: "Is it due to the greenness of the sewage? Would a large container make a difference?"

Mr. Tennant: "Perhaps Dr. Pomeroy can answer that."

Mr. Anaya: "How do you know, or can you find out, how many cubic feet of gas you can generate from 1,000,000 gallons of sewage?"

Mr. Tennant: "That depends for one thing on the amount and character of solids in the sewage. About 1 cu. ft. of gas per capita per day if it is an oxidizing plant where the solids are retained in the plant."

Mr. Pomeroy: "I think the B.t.u. variation indicated (400 to 700) is not what would normally be experienced in tanks in operation. When tanks first operate they give off gas of low heat value, but when digestion is well established the gas will be of better and more uniform quality. The heat value of the gas depends on the methane content. Tests indicate that the maximum limits of the methane content from most digestion tanks will be 60-75%, and usually it will be between 65 and 70%, so no large changes in heat value are to be expected.

"The heat values of gases are usually given in terms of the total heats of combustion, including the heat of condensation of the water. The efficiencies of gas engines are figured on net heats of combustion, which for sludge gas are 11% lower than heats of combustion."

Mr. Bishop: "Have you any information as to the relative value of different kinds of sewage gas? Say in cannery refuse, is the gas of any value or will it kill the gas from domestic sewage?"

Mr. Pomeroy: "As long as digestion tanks are functioning in a manner satisfactory to produce the type of changes sought in the anaerobic digestion of sewage sludge, the gas will not vary much in composition.

"As to cannery wastes, skins and seeds will not digest but the juices and fleshy parts of the fruits will digest and the gas produced will not be essentially different from that produced in tanks having no such wastes. This discussion does not apply to such wastes as may be found to upset the digestion process and produce an acid, odoriferous and poorly-digested sludge.

"Some work has been successfully done on the digestion of beer slop, and considerable amounts of garbage may be added to sludge without harmful results."

SAN BERNARDINO SEWAGE DISPOSAL PLANT

By L. E. MALLOY*

Prior to the construction of the present disposal plant, the sewage from the City of San Bernardino was carried to the Delta Farms Tract approximately five miles southeast of the city where it was used for irrigation and filtration on several hundred acres of land, mostly planted to fruit trees and asparagus. This method of sewage disposal was entirely unsatisfactory as well as unsanitary as the sewage was not screened or chlorinated. During the winter rains the land soon became saturated and the raw sewage was carried into the adjacent creeks. In 1928 a bond issue for $650,000 was voted by the people for the construction of a modern plant and sufficient outfall sewers to provide for a population of 60,000 people. After consulting with several engineers, the Currie Engineering Co. was awarded the contract to design and superintend the construction of a disposal plant of the Imhoff type with trickling filters and secondary sedimentation. The work was completed and the plant put in operation in February, 1929.

The Plant is located directly south of the city and consists of four 40-ft. diameter Imhoff tanks located on either side of the main control house which is of two story construction. The sewage enters the control room through two 6,750-ft. inverted syphons, 15 and 18 in. in diameter. A third syphon 24 in. in diameter is not used at the present time but will be required when another unit is built. The influent is measured through three Simplex meters of Venturi type and is conveyed to the Imhoff tanks which have a retention period of 45 minutes on maximum hourly flow. From the Imhoff tanks the sewage is carried through the dosing chambers to the trickling filter beds which are about 200x260 ft. in area. From the trickling filters, the water is taken to a secondary clarifier of 40 ft. in diameter from which the effluent is conveyed through 1,600 ft. of 30-in. outlet pipe to Warm Creek where it is discharged and used for irrigation.

The plant was designed to take care of a maximum hourly flow at the rate of 7 m.g.d. At the present time the average daily flow is 3.3 m.g.d. The time consumed for the sewage to pass through the plant is approximately 4 hours and 15 minutes, and tests show the plant to be operating very successfully.

As the disposal plant is located near the main highway and surrounded by farms it is essential that odors be kept at a minimum. To accomplish this, besides through chlorination which will be described later, the gas vent areas of the Imhoff tanks have been covered and provided with gas collectors from which the gas is conveyed and stored into two 750-cu. ft., lift type, gas holders. The gas vent areas in the circular Imhoff tanks are sectors of circles and as each unit consists of two tanks, it is necessary to provide gas collection for eight separate sectors. Each collector consists of a casting covering a 4-ft. circular opening in the concrete cover of the gas vent area.

Through the center of the casting is a vertical shaft provided with a large hand wheel and a specially designed revolving rake so arranged

* Assistant Engineer.

that the floating sludge directly under the casting is broken up and pushed down. The casting is set at such an elevation as to be about 6 in. lower than the normal water level in the tank. Each collector is provided with a 6-in. cast iron drain with the necessary gate valves, and at two points opposite this drain, water connections have been provided so that excess sludge may be washed directly to the drain line.

Especial attention is called to this drain, as it plays an important part in the proper functioning of the gas collectors. These drains should be operated often in order to prevent the formation of the heavy scum blanket, as a heavy scum is practically impossible to soften and remove, if allowed to form. Originally the collectors were drained once every two or three months and this difficulty was encountered. At the present time the drains are opened each week for ½ hour which prevents the formation of the scum.

The operators are instructed to turn the hand wheel two or three times daily and to run a small amount of fresh water into each collector. We have found, however, that if the flow into the tanks is not reversed at least every 3 or 4 weeks, the wheel will be hard to turn on the two collectors near the inlet, but that after reversing the flow, the floating solids seem to soften within a short time.

The gas which is collected, amounting to 25,000 cu. ft. per day can be used to operate a 40 h.p. 4 cylinder Hercules gas engine direct connected to a 28 kva, 220 volt, 50 cycle, 3 phase electric generator designed to operate at 1000 r.p.m. The generator is equipped with the necessary direct current exciter and voltage regulator. This equipment was installed as an emergency measure in case of failure of the electric power or to reduce the load at the time of greater demand in the mornings, when washing around the plant, skimming of the tanks and pumping of the sludge is done.

The power generator can also be used to operate a 15 h.p. motor on the deep well pump for the water supply, which is obtained from a 150-ft. well and discharged into a 4000-gal. hydro-pneumatic tank, operating at pressures from 45 and 90 lbs., and also to run the Barne sludge pump, which is operated twice daily, to remove the sludge from the secondary clarifier back into the stack carrying the influent to the plant. The total power consumption at the plant, therefore, not including the lighting, will consist of these two motors together with two 1 h.p. motors on the skimmers and a 3 h.p. motor on the clarifier secondary tank. As the load is not excessive or constant, the power equipment is held in reserve in case of an emergency.

In the operation of the Imhoff tanks we have found that if the sludge level is kept 6 ft. below the slot to the sludge chamber we are not bothered from gas escaping from the tank. This necessitates sludging every three months. We have always found the sludge to be thoroughly digested, dark in color and free from offensive odors. At the time of construction, the Imhoff tanks were provided with mechanical skimmer which since has been replaced by Mr. Currie with patented air skimmers which are far more successful due to their ease of operation, simplicity of construction and their failure to agitate the water during the skimming operation.

At the present time the sewage is chlorinated at several points; the first being at the Orang Show building at the head of the invert siphon where equipment has been installed to accomodate 1-ton chlorine containers and one 300-lb. Wallace & Tiernan chlorinator. Chlorine is fed into the siphons at the rate of 180 lbs. per day from 7 a. m. to 8 p. m., at which time it is reduced to 150 lbs. This has proven successful in the elimination of the odors as the sewage enters the control room. The sewage is again chlorinated in each dosing chamber from 7 a. m. to 7 p. m. at the rate of 60 lbs. per day, and in the secondary clarifier 180 lbs. during the time of heavy flow and reduced to 30 lbs. at night.

At the present time we are making tests in regards to the different chlorinator settings in cooperation with E. A. Reinke of the State Board of Health and the results that we have obtained by using 0.1 cc. and 1.0 cc. samples from the final tank in Dunham fermentation tubes would indicate the settings that we are now using thoroughly eliminates the B. Coli as well as keeping down the odors to a great extent. These settings call for the use of 290 lbs. of chlorine per day. Storage is provided for eighteen 1-ton containers and overhead tram-rails and hoisting equipment make it possible for one man to replace the empty containers on the scales. The chlorinating equipment at the plant consists of two 200-lb. chlorinators and one 300-lb. Wallace & Tiernan machine. The outlets of the machines are so arranged and controlled through hard rubber valves that one or two machines may be used for final chlorination or for chlorinating the effluent from the Imhoff tanks at the entrance to both of the dosing chambers. The present set-up calls for the two 200-lb. chlorinators to discharge into the dosing chambers and the 300-lb. machine into the final. It is interesting to note that no color with orthotolidine can be obtained in the dosing chamber although the dosage is in excess of 5 ppm. Most of the odors from the plant at the present time originate from the filter beds when they are in operation. Whether additional chlorination in the dosing chambers will remedy the situation will have to be determined. The beds are operated for a four months period and then allowed to stand for 10 days to dry them out.

In June 1935, when the management of the disposal plant was placed under the jurisdiction of the Municipal Water Department, the plant was completely renovated and all equipment put in first class condition. A thorough study of the plant was made and a complete set of tests and records was decided upon as follows; (1) a record of the daily flow in gallons of sewage entering the plant through each siphon, (2) records of the settings of the chlorinators and the total amount of chlorine used daily, (3) a test to be made for hydrogen sulphide using the antimony potassium tartrate method, (4) samples to be taken from the final tank from which putrescibility tests are made in accordance with the American Public Health Association Standard, by the use of methylene blue, (5) pH determination at the stack before the raw sewage enters the Imhoff tanks, (6) the settling solids determined at the stack and both sets of Imhoff tanks and (7) residual chlorine readings by means of a Wallace & Tiernan comparator made in the secondary

clarifier and at the point where the effluent is discharged into Warm Creek. This is necessary because the stream flows several miles through farming lands before entering the irrigation canal and we try to maintain a residual reading of 0.1 ppm. to guarantee the removal of all B. Coli. The county sanitary inspector has made several tests along Warm Creek and gives us a B. Coli reading of "zero" which shows that the settings that we are now using are proving successful.

At the College of Medical Evangelists, which is located at Loma Linda a few miles east of San Bernardino, there are classes in both medical and nurses training. In the course of their work, they visit our plant several times a year taking samples of the sewage and make a report of the bacterial count. The results they obtained from tests made June 11, 1935 are as follows: The raw sewage, which had previously been chlorinated at the Orange Show plant, showed 1,375,000 organisms per cc. At the Imhoff tanks, 1,215,000 organisms per cc. and in the filter beds 312,000 and in the final tank only 860. As this includes all organisms it shows the splendid efficiency of the system we are using.

The only revenue derived from the disposal plant at the present time is from the sale of sludge which is taken from the Imhoff tanks and dried upon two sludge beds 50 x 264 ft., underdrained with sand, fine and course rock, and tile. The drying period is dependent upon atmospheric conditions but is ordinarily 2 to 3 weeks. Dry sludge is removed from the beds by forks and trucked away to be used for fertilizer. During the last fiscal year there was approximately 18,000 cu. ft. of sludge sold for $1500, which is approximately 15% of the total operating cost of the plant per year. In San Bernardino there is a normal sewage condition due to the absence of canneries and other industrial wastes so no unusual problem is encountered.

In the past years it has been difficult to operate the plant in a satisfactory manner due to the lack of funds appropriated by the city for the purchasing of equipment and supplies. Since the water department has taken over its management, and realizing the necessity of sanitation and the abolition of any nuisance, sufficient money has been appropriated from the water fund to operate the plant as it was designed, and to keep sufficient records and data to guarantee that any chances of contagion from the plant be kept at a minimum. In this respect we are trying to cooperate with the State Board of Health in every possible manner and have received valuable assistance from Mr. Gillespie and his associates.

COMMENTS ON STOCKTON PLANT

By FRED WEST

Published in the **Sewage Works Journal.**

COMMENTS ON THE MARIN COUNTY SANITARY DISTRICT'S PUMPING PLANT

By A. B. SHEARER

I was somewhat apprehensive about coming up here but after listening to the other discussions I have more courage. I did not prepare a paper so I am offering my remarks in a different form from the comprehensive and elaborately detailed papers which have been read here today.

It was just a year ago when I took charge of our plant. I inherited a unit of three very badly worn out pumps. They were of the vertical centrifugal type and the designer had not intended them to be used for sewage. They were designed as horizontal centrifugals with babitt bearings and not fitted with a proper packing gland. The result was they wore badly and the shaft and the runner weight were suspended from the thrust collar which was held by means of a set screw. This had become loose, allowing the runner to drop and the weight of the shaft was riding on the bottom. Wear had taken place to the point where it sounded like an old Model T Ford.

I reported these conditions to our board, which was also new in office, and the question came up as to what to do about it. I inquired and found we did not have sufficient money for new pumps. I had to make repairs as best I could. The board had picked me because I have been in the mechanical business all my life. I dismantled the pumps one at a time. I took the housing and fitted a packing gland and a ball bearing on the top of the housing. Inquiring the price of ball-bearings I found they wanted $9.00 apiece, but I bought used ones for $1.00. When I inquired the price of a runner (the pumps were clogging and rendering very low efficiency—pumping 280 g.p.m.) I found the price was $38.00. I proceeded to make a pattern which I had cast for $4.97. After this was fitted to the assembly, by actual test we found we were pumping 675 g.p.m. I made the curve of the impeller channels so as to provide as large a waterway as possible. While the pumps ran very nicely, they clogged almost immediately. The increased volume caused trouble from rags. I tried to overcome the clogging by use of screens, but enough rags would work thru so that the impellers would clog anyway. I then proceeded to study the matter further and finally designed another runner. I took out the two liners of the pump housing and put the housing on a lathe. I turned out as much iron as safety would permit and made another runner with two blades. In removing two blades, I felt I had to get enough surface area with the remaining two blades as I had on the original four, so I increased the depth of the impeller to 3 inches as against the original 1¾ inches. After the impeller was installed and balanced, I found that the pump would put out 670 g.p.m. and absolutely would not clog. I have tried to clog them with rags, but could not. I have increased the capacity about 250%, reduced the electrical bill 50%, and delayed the buying of new equipment for some time.

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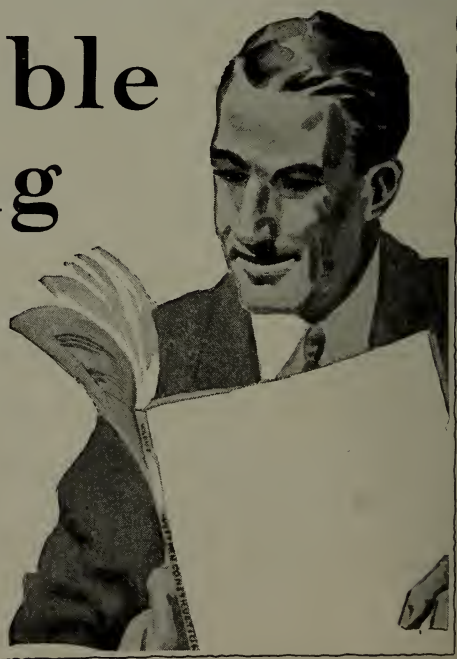
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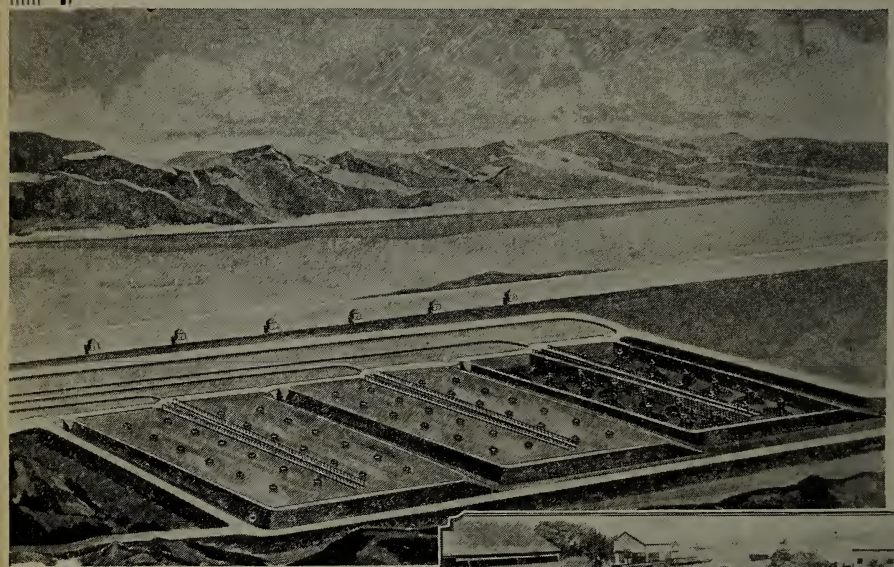
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CALIFORNIA SEWAGE WORKS JOURNAL

Official Publication of the California Sewage Works Association

Vol. VIII :: 1936 :: No. 2

Minutes of the Eighth Spring Conference
At Ontario, California
April 24 and 25, 1936

•

Experiences with Digester Foaming

•

Recent Innovations in Sludge Dehydration and Incineration

•

The Beaches of California and Their Protection

•

Sewage Plant Operation Symposium:
Whittier - Pomona - Ontario - Colton

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Committee Reports



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EIGHTH SPRING CONFERENCE
Ontario, April 24 and 25, 1936

●

PROGRAM

Morning

INSPECTION CARAVAN

8:00—Convene at the Pasadena Sewage Disposal Plant.
9:15—Arrive Whittier Sewage Treatment Plant.
10:15—Arrive Pomona Sewage Disposal Plant.
11:15—Arrive Ontario Sewage Disposal Plant.
12:00—Register; Hotel Ontario, Ontario.
12:30—Luncheon, Hotel Ontario.

Afternoon

1:45 to 5:00—Papers and Discussions:
Hotel Ontario—

1. Report and discussion of Committee on Operators' School.
2. Report and discussion of Committee on Licensing of Operators.
3. Report and discussion of Committee on Safety Regulations.
4. Plant Operation Symposium:
 Whittier—M. R. Bowen, City Engineer.
 Pomona—F. C. Froehde, City Engineer.
 Ontario—Austin Burt, City Service Manager.
5. "Heat Exchange Process Utilized in Incineration of Stack Gases at Pasadena Sludge Drying Plant."—A. W. Wyman, Plant Superintendent.
6. Review of data presented at the New York State Sewage Works Association and the Sanitary Section of the American Society of Civil Engineers, New York, January, 1936—C. G. Hyde.

Evening

6:30 to 9:00—Dinner—Hotel Ontario.
Address by George Hjelte, Superintendent of Parks and Playgrounds, Los Angeles County. "Beach and Shore Pollution."

Friday, April 24th

Morning

INSPECTION CARAVAN

8:30—Leave Hotel for San Bernardino.
9:00—Arrive San Bernardino Treatment Plant.
10:00—Arrive Redlands Treatment Plant.
11:00—Arrive Colton Treatment Plant.
11:45—Ontario (visit orange pulp dryer).
12:30—Luncheon: Hotel Casa Blanca.

Afternoon

1:30 to 5:00—MEETING: Hotel Casa Blanca.

1. Plant Operation Symposium:
 San Bernardino—L. A. Hosegood, Assistant Water Superintendent.
 Redlands—Geo. S. Hinckley, City Engineer.
 Colton—Ezra West, City Electrician and Plant Operator.
2. "Experiences with Digester Foaming"—Harry E. Schlenz, Vice President Pacific Flush Tank Company.
3. "Recent Innovations in Sludge Dehydration and Incineration"—Wm. B. Senseman, Combustion Engineerig Corp.
4. "Effect of Salt Water Infiltration on Newport Sewers and Comments on H_2S Control by Scott-Darsey Process"—R. L. Patterson, City Engineer.

Ninth Annual Convention
CALIFORNIA SEWAGE WORKS ASSOCIATION

September 11 and 12, 1936

at

Santa Monica, California

AMERICAN SHORE & BEACH PRESERVATION ASSOCIATION MEETING

September 24 and 25, 1936

at

Los Angeles, California

On Thursday and Friday, September 24 and 25, the American Shore and Beach Preservation Association will convene for its annual convention at the Hotel Biltmore in Los Angeles. In addition to discussions by National authorities relating to the physical destruction or preservation of marine beaches, it is the intention at this meeting to also discuss shore water pollution from oils and sewage; the presentation of the latter topic to be given by an individual chosen from the California Sewage Works Association membership.

In the following pages of the JOURNAL will be found the text of the address presented at the Ontario meeting of C. S. W. A. by George Hjelte, vice-president of the American Shore and Beach Preservation Association, and an individual thoroughly conversant with the Association's aims and objectives. Our Association has pledged limited financial support to Mr. Hjelte for the purpose of defraying the limited expenses of such a convention. This has been done because of the border-line contact between our Association and Mr. Hjelte's.

The convention promises to be interesting and instructive, the papers to be presented will deal with the situation both from a National standpoint and from the point of view of the Pacific Coast, and members are urged to watch appropriate current periodicals for an outline of the completed program and to attend the convention of the American Shore and Beach Preservation Association if possible.

MINUTES OF THE EIGHTH SPRING CONFERENCE CALIFORNIA SEWAGE WORKS ASSOCIATION

The eighth spring conference of the California Sewage Works Association convened at Ontario, California, about noon on April 24, following an inspection during the morning of sewage treatment plants at Pasadena, Whittier and Ontario.

After luncheon the meeting was called to order by President A. M. Rawn and reports were received from committees on plant operators' school and licensing plant operators. These reports were favorable and after some discussion it was agreed to have a new combined committee make a report at the Fall convention outlining a definite plan of procedure.

After hearing a report from the Committee on Safety Regulations it was also decided to have a new committee report on this matter at the Fall meeting, with definite proposals for consideration of the Association.

Interesting features of their respective treatment plants were briefly described by M. R. Bowen, city engineer of Whittier, F. C. Froehde, city engineer of Pomona and Austin Burt, city service manager of Ontario.

Mr. A. W. Wyman, plant superintendent at Pasadena, next presented an excellent paper on "Heat Exchange Process Utilized in Incineration of Stack Gases." This process is an innovation in treatment of the disagreeable odors emanating from the exhaust gases in the sludge drying process. After passing the gases through a dust removal tower they enter successively two heat-transfer towers which are filled with rock. Cost of deodorizing by this new method is greatly reduced.

Prof. C. G. Hyde, University of California made the concluding address of the afternoon session presenting a review of data from the Federation of Sewage Works Associations and the American Society of Civil Engineers annual meetings which he attended in New York City last January. He said several outstanding papers were presented by California men.

George Hjelte, superintendent of playgrounds and recreation, Los Angeles City, delivered an inspiring address at the evening dinner meeting on th subject of "Beach and Shore Pollution." He mentioned the low per capita cost of beach recreational areas in comparison with other city playgrounds and compared the twenty-seven miles of publicly owned beaches in the Los Angeles metropolitan area with the total of sixteen miles in New York State and made a strong plea for prevention of oil waste and sewage pollution of the beaches.

On the following morning the members and guests were organized into a caravan visiting the sewage disposal works at the cities of San Bernardino, Redlands and Colton. Returning to Ontario, the group inspected an orange pulp drying plant.

An afternoon session followed the luncheon at the Hotel Casa Blanca, Ontario. A paper on sludge drying by William B. Senseman was illustrated with lantern slides. He discussed the new machinery of this type which has recently been installed at the Calumet treatment plant in Chicago, where sludge is completely incinerated.

Considerable discussion by designers and operators in attendance followed the presentation of a paper by H. E. Schlenz of Chicago on "Experiences with Digester Foaming." A number of causes for this trouble were set forth: changeable character of the raw sludge, insufficient digester capacity, flaws in gas vents and changes in pH.

City Engineer, R. L. Patterson, of Newport Beach spoke briefly of infiltration into sewers which are generally below sea level. He also outlined the installation and use of the Scott-Darcy process in the sewerage system to eliminate odor complaints and aid in treatment.

A summary of operating data on the 200 H.P. gas engine being operated on sludge gas by the Los Angeles County Sanitation Districts was given by C. F. Tennant, chief operator.

The meeting was one of the most successful held by the Association and indicated an expanding interest in the organization by those connected with the field of California sanitation. Many new memberships were secured and the registration totaled 115, exclusive of friends and families.

FRED D. BOWLUS, Secretary-Treasurer.

The following papers are published
in
SEWAGE WORKS JOURNAL
July 1936

Heat Exchange Process Utilized in Incineration of Stack Gases at Pasadena Sludge Drying Plant

By A. W. WYMAN

Operation of San Bernardino Treatment Plant

By L. A. HOSEGOOD

Effect of Salt Water infiltration on Newport Sewers and Comments on H_2S Control by Scott-Darcey Process

By R. L. PATTERSON

Experience with Sludge Gas Engine Operation

By C. F. TENNANT

SECOND REPORT OF THE COMMITTEE ON SEWAGE WORKS OPERATORS' SCHOOL

In September 1935 at Palo Alto, this Committee presented a report on the advisability of a School for Sewage Works Operators, in which report we stated there did not appear to be sufficient interest at that time to justify an active attempt to establish such a school. The Committee has been continued with the request from President Rawn that we make further contacts with operators and city officials for the purpose of presenting the advantages of training for sewage works operators more completely than had been done heretofore.

The Committee has been of the opinion that written communications on the subject were of little value and that it was necessary to contact operators and city officials personally in order to determine whether a Sewage Works Operators' School could be established.

The members of the Committee have during the past six months gone to a considerable number of communities in the state, both north and south, and interviewed personally both operators and city officials. As a result of this work, the Committee is now of the opinion that there is sufficient interest in the project to justify the establishment of a School for Sewage Works Operators in California. At the present time, it appears that operators from the following communities will attend the first session of such a school:

Los Angeles (Hyperian Plant)—5 Operators	Roseville
Oxnard	Colton
Ojai	San Bernardino
Newport Beach	Ontario
Whittier	Cloverdale
Marin County No. 1	Stockton
Davis	Chico
Palo Alto	Healdsburg
Ukiah	Winters

In addition, it is possible that if a school is established a number of other communities will decide to send their operators, among such possibilities being:

San Francisco (Golden Gate Plant)	Fresno
Burlingame	Atwater
San Mateo	Seal Beach
Gilroy	Redlands
Salinas	Visalia

In addition to actual operators, it is possible that such a school may attract the attendance of some senior students and recent graduates from universities giving curricula in sanitary engineering.

The first session of the school apparently would have an attendance of twenty or twenty-five operators, which is a sufficient number to justify the establishment of the school.

It is the opinion of the Committee that if this Association inaugurates a program of voluntary certification of operators, still further interest

in the proposed school will be engendered. The Committee therefore makes the following recommendations:

1. That the California Sewage Works Association approve the general idea of the establishment of a school for sewage works operators in California.

2. That the first session of the school be held in southern California, preferably in the vicinity of Los Angeles, and that thereafter the sessions be alternated between the northern and southern parts of the State.

3. That it will probably be desirable to hold the school immediately preceding or following either the spring or the fall meeting of this Association (or both meetings) so that those who attend the school can also conveniently attend the meetings of this Association if they so desire.

4. That the fee charged should not exceed $10.00 per student per session. The Committee realizes that such a fee will not cover the cost of instruction, but we believe that part of the cost of instruction can be met, at least in the first few years until the school is well established, by financial assistance from various sources and possibly by direct cooperation from certain official agencies.

5. That this Association contribute to the financial support of the school such amount of money as may be needed or available, subject to the approval of the Board of Directors of the Association.

6. That the matter of sponsorship of the school should be given further investigation by a subsequent Committee. This Committee has not studied this phase of the subject and makes no recommendations thereon. We suggest that the following possibilities as sponsors should be investigated either for single or joint sponsorship:

(a) The Association itself.
(b) The Bureau of Sanitary Engineering of the State Department of Public Health.
(c) A University or Universities.

7. That this this Committee sees no reason to change its previous recommendation as to methods of teaching presented in the report of September 1935 (that the instruction should be thoroughly practical rather than merely theoretical) but recommends that the arrangement and content of the subject matter be restudied and a further report thereon rendered at a later date. There is some differnce of opinion among the members of the Committee on the subject of content and arrangement of curriculum, and this phase of the matter we believe should be left to a subsequent Committee to study and decide.

8. That a subsequent Committee investigate the teaching facilities which could be available as well as the teaching personnel, as both will have an important bearing on the locations of the school and the time at which the school is held.

9. That upon presentation of this report the personnel of this Committee be discharged and that a new Committee, consisting principally of members residing in southern California, be appointed to make all arrangements for the proposed School for Sewage Works Operators, as

to sponsorship, curriculum, instruction staff, location and finances, and that the first session of the school be held either in the autumn of 1936 or the spring of 1937 as the Committee may advise after due study, subject to authorization by the Board of Directors of this Association.

Respectfully submitted:

A. P. BANTA
F. A. BATTY
JOHN JACOBSEN
A. B. SHEARER
JOSEPH WAGNER
HAROLD F. GRAY, Chairman

DISCUSSION

Mr. Kennedy: I move that this report be accepted and that the recommendation therein contained with reference to the appointment of a new committee to formulate arrangements for carrying on the work of this committee be adopted. Seconded by Mr. Jewell. Motion carried and so ordered.

REPORT OF COMMITTEE ON LICENSING OF OPERATORS

At the 8th Annual Convention of our Association this Committee was instructed to bring in a detailed report covering the classification, qualification, and administrative procedure and the cost involved of putting into practice the licensing or certification of operators, in accordance with the resolution of the Association adopting this plan in principle.

It is to be recalled that it was felt desirable to act along parallel lines to similar action contemplated by the California Section of the American Water Works Association.

A. W. W. A. PROCEDURE—CALIFORNIA SECTION

In connection with the A. W. W. A. procedure it is of interest to note that at the annual meeting in October, a committee consisting of Messrs. R. F. Goudey, George W. Pracy and Carl M. Hoskinson made a report to the Executive Committee of the California Section of the A. W. W. A. which resulted in a resolution being adopted endorsing the principle of voluntary licensing of operators, authorizing the appointment of a committee of three to administer such licensing and setting up classifications and qualifications.

Subsequently, the committee to administer this licensing was appointed, consisting of R. F. Goudey, Chairman, together with Prof. S. B. Morris and C. G. Gillespie.

The classifications and qualifications used by this committee are those adopted by the National A. W. W. A. Committee.

Attached to this report are copies of a summary of the procedure setup together with plans for examination and application in certificate forms.

While all of the details in this connection have not been finally approved by the A. W. W. A. Committee, it is felt that they will be adopted essentially as is.

In connection with the following recommendations the desirability of action paralleling that of the California Section of the A. W. W. A. has been kept in mind.

RECOMMENDATIONS OF COMMITTEE

It is the recommendations of your Committee that a resolution approving the following be adopted:

1. There shall be three classes of operators as follows:

Class I. (a) Operators in cities of more than 5,000 population employed to operate complete treatment plants producing oxidized and stable effluents and having approved laboratory facilities and equipment.
(b) Operators in cities of more than 100,000 population in charge of plants consisting of chemical precipitation; settling tanks and separate sludge digestion; and other plants of a similar nature.
(c) Operators in cities of over 500,000 having responsible charge of disinfection and/or screening.

Class II. (a) Operators in cities of 5000 or less in charge of all plants listed under Class I (a).
(b) Operators in cities of 100,000 or less in charge of all plants listed under Class I (b).
(c) Operators in cities of 250,000 to 500,000 population in charge of disinfection and/or screening.

Class III. (Operators in cities with less than 250,000 population in charge of screening and/or disinfection.

2. That the qualifications for sewage works operators be the same as those set up for Class I, II and III operators for the A. W. W. A., and adopted by the California Section of the A. W. W. A., except that in connection with first class operators, graduates in Sanitary Engineering and Public Health be given a preference in the way of leaving their experience requirement at one year; the experience requirements for Chemical Engineering graduates be raised to two years; and add for eligibility a graduate with a B. A. degree with courses in water chemistry and bacteriology, with three years experience. Also that in connection with second class operators that graduates in Sanitary Engineering and Public Health be eligible without experience.

3. That a committee of five be appointed to administer the voluntary licensing of operators, at least two of the members of the committee to be operators, one from the northern part of the State and one from the southern part of the State, with the Consulting Engineering profession, the University Teaching profession, and the State Board of Health as possible additional groups to be represented on the committee. Appointments should be for a term of years, and staggered to give continuity of policy.

4. That operators aplying for licensing before some initial closing date to be set by the committee, be classified without an oral or written examination, the classification to be based upon experience and training qualifications only; it being understood however, that if the Committee on Licensing feels that any applicant is not entitled to be fully licensed, it may issue a temporary license which will be good until the next oral or written examination is held, any subsequent licensing to depend upon the result of such examinations.

After the initial closing date, licenses will be issued only to those who have the proper qualifications, and who have in addition passed such oral or written examinations as may be required by the committee, and which will be held during the Annual Convention period of the C. S. W. A.

5. That a license fee of $1.00 shall be required for the original application, and for any subsequent application for higher classification.

Licenses shall be renewed annually or possibly bi-annually without cost, on receipt of information that the operator is still employed at the plant for which the license was issued.

* * * * *

In connection with the above it is felt that the licensing fee of $1.00 will in a large measure at least, pay the very nominal expenses of the costs of administering this licensing procedure. However, it should be pointed out that membership on this Committee will, at least for the first several years, involve an appreciable amount of work to make the plan successful.

If the C. S. W. A. establishes schools or short courses for operators, it would undoubtedly be desirable to give proper credit to operators for the completion of such courses in connection with their qualification for licensing; the licensing and the schools for operators would obviously mutually supplement each other.

Your Chairman wishes to acknowledge the very fine assistance he has had from the members of this Committee and particularly from Messrs. H. B. Hommon, R. F. Goudey and E. A. Vaughn.

Respectfully submitted,

A. C. BEYER, Chairman,
Committee on Licensing
of Operators, C. S. W. A.

DISCUSSION

Mr. Rawn:

This is a subject in which we should take a great deal of interest. Licensing of operators has gained considerable impetus during the last few years. The licensing of an operator is presumed to qualify him at least as to his experience. To start the discussion I am going to mention one or two things which will perhaps bear some clarification; the point with reference to operators in "cities" should be clarified to include also District, or joint-undertaking operators. Any recommendations that are adopted by the C. S. W. A. in the form of a resolution should define what an operator is; also what constitutes "experience" so that a

licensing committee will have a general guide for their actions and will know what is to constitute "experience." As this report contains nothing which calls for a motion, but only the recommendation of the Committee that a resolution approving it be adopted, it would not be beyond the scope of the Board of Directors to appoint a new committee and ask it to revise the draft. Thus, at the fall meeting the committee might submit in more complete form the information which will be required if we undertake voluntary licensing of operators.

Mr. Goudey:

May I call attention to the fact that the Water Works Association has combined its two committees, "Licensing of Operators" and "Short Schools." Why not do the same in the C. S. W. A.?

Mr. Rawn:

That was suggested at the last annual meeting and, I believe, approved.

Mr. Reinke:

Mr. Jacobson asked me to say something with regard to Mr. Gray's report. It seems that a number present have the impression that there is lack of interest in an Operators' School. I was very much surprised to learn that Mr. Jacobson had gone to the mayors of three small communities in Northern California and they all agreed to send the plant operator to a school. They also considered that voluntary licensing would be a fine thing. We should hear from the operators. This is an opportunity for the Association to do something on the question of schools and improved operation. I think the same committee should be continued, or in appointing the new committee, a majority of the old members should be retained.

Mr. West:

I'll state for myself that of the seven operators present, I seem to be about the only one showing any interest in addition to what we learn in practical operation. Some people think that all an operator has to do is to screw down grease cups and collect his salary. Mr. Jacobson was down to see me and wanted an immediate answer to what I thought the city council would do with regard to sending an operator to school. I went to see the City Manager and he was out of town. The Mayor was also out of town. Finally when I did contact the Mayor he said he did not know what it was all about but that whatever I thought would be of benefit he was for it. When I approached him last Tuesday about the possibility of my attending this conference he said: "Believe me, you have my approval . . . also financial assistance—in going to these conventions." When I asked the City Manager he said: "Well, I don't know anybody else who would go unless you do. What do you want?" I said, "Plenty." I really was very gratified when he readily consented to everything. Personally, I don't think enough interest is being shown by the officials of other cities. They seem to think the operator should bear all the expense. We cannot afford that.

Mr. Ely:

I would enjoy going to a school of this kind. I have not been an operator for very long and the more I travel around the more I find to

learn. In taking action on this matter, our purpose should be to give each other the benefit of what we know. The school must be practical. The man in charge of such a school must be a man who has had practical experience. I do not want to go there and listen to some "Ph. D." who does not know what the inside of a plant looks like. Also in regard to licensing: the man who is licensed feels that he has some protection for his job. He should be able to pass a reasonable examination. It seems to me that the classification for licensing should not be based on the size of the town but on the work the operator has to do and on the size of the plant.

Mr. Rawn:

I think the two are directly related.

Mr. Smith:

Mr. Goudey's point regarding combining committees is well-taken. The school will have in attendance not only operators but prospective operators.

Mr. Rawn:

I don't mean to contradict anything in the report, but there are operators and assistant operators. There are in Mr. Wyman's plant at Pasadena for instance, a superintendent, chief operator, and four or five shift operators. How are the assistants to be classified? The rules laid down for a committee on licensing to follow must be reasonably clear and explicit if harmony is to result.

Mr. Ingram:

Licensing of operators might be the best means of getting city officials interested in their sewage disposal plants. My experience has been that the city officials do not know and do not care to know much about their plants. If the operators were required to be licensed and a school were established it might be the means of getting the city officials to give financial support. Although I am not a plant operator I feel that I can learn a great deal in attending the proposed short course, just for information, not from any idea that I would get a sewage disposal plant operator's license.

Mr. Updegraff:

Regarding the relationship between city officials and plant operators: Messrs. Rawn, Bowlus and I attempted to lay the ground work a bit in "Western City." I would be glad to act as liason man to present this problem in person before the League of Municipalities district meetings and tell the officials why they should send their operators to this school.

G. A. Parkes:

Many engineers would be pleased to attend a practical course of training. It seems to me the terms "voluntary licensing" and "operators" should be more clearly defined. What is "voluntary licensing"? What does the term imply?

Mr. Rawn:

The term "voluntary licensing" is in contrast with statutory licensing form. As applied here it means that a man will submit himself voluntarily to examination to a Board formed of Association members, and that he will be classified and given a certificate entitling him to that

classification. Seven classifications are recommended by the Committee. It would be, in effect, an endorsement by this Association through its appointed committee, that that individual was qualified, in their opinion. It does not necessarily mean that a man must be registered in order to hold his position.

E. A. Reinke:

Would it be obligatory to employ a licensed operator?

Mr. Rawn:

No.

Mr. A. B. Shearer:

Regarding the proposed Legislative Act bearing on employees coming under Civil Service would there be any conflict with this proposal?

R. F. Goudey:

Civil Service will recognize any experience. An operator who is voluntarily licensed should receive a higher rating under the proposed Civil Service law than if he were not so licensed. In a recent survey it was found that five states have compulsory licensing and 15 states have voluntary licensing. It seems advisable to start out with voluntary licensing to determine the need for a recognition of such licensing before trying to make it compulsory. Voluntary licensing should advance the standing of the operator in his final rating for Civil Service.

The reason the state licenses operators of any sort is on the assumption that it is a safeguard for the public health or public safety. Statutory registration or licensing of operators if ever undertaken should be on the grounds of public health and safety. This is the only valid basis.

Mr. Rawn:

The recommendations of the Committee are to the effect that the following be adopted: (1) General classification of operators with amendments to give advantage to men with university educations, (2) Licensing board to be composed of five members, (3) Operators to apply prior to a fixed date without oral or written examination. It is the sense of this meeting that those recommendations be adopted and form the basis of the instructions for a Committee to draft this resolution in final form.

C. C. Kennedy:

I cannot understand the reasons for basing classifications according to population. Would it not be an injustice to the operator to put him in a class of a small city? Why split it up into various populations? Why not various types of treatment?

R. F. Goudey:

It works the other way too. For instance, consider a screening plant. You would not want the operator of a plant serving 5000 population to hold the license of the same rank as, say, the Los Angeles screening plant operator. Increase in population must be considered. A large city may have low grade treatment, but it takes a good operator and a good plant. We are indebted to Mr. Harry Martin for the wording of these classifications which are well thought out and merit careful consideration. I can see where there is need for broadening the scope of the meaning of the word "city" and such terms as "chief operator" and

"assistant operator," also the matter of experience should be amplified. Class 1-A license means experience. The Committee should set up its rules on that basis.

Mr. Rawn:

The Chairman will entertain a motion to the effect that the recommendations in the committee report be adopted and that a new committee be appointed to prepare a final report on Schools and Licensing to be presented at the Annual Meeting.

Mr. W. T. Knowlton:

I move that the report be adopted. Motion carried and so ordered.

REPORT OF COMMITTEE ON SAFETY REGULATIONS

Procedure, Regulations and Apparatus to Insure Safety in the Maintenance, Operation and Reconstruction of Sewers

The object of formulating these rules for safety regulations is to lay down and establish a simple and practical method of procedure and practice that will protect the lives and health of men at work in and about sewers. The gases in our sewers are constantly increasing in number of kinds and potency due to new manufacturing wastes emptied therein, causing an increasingly dangerous condition against which the workman must be protected.

PRECAUTIONS OF PROCEDURE

(Requiring Little or No Apparatus)

Precautions Against Traffic

Available trucks, autos or wagons shall be parked in line with the traffic, close to the manhole which is to be opened to form a barrier against traffic. "Men at Work" signs shall be placed in front and in back of the manhole, or in front and back of the trucks, etc., forming the barriers.

In case trucks, etc., are not available "Street Closed" signs and barricades shall be set up instead of said trucks and a man with a red flag shall watch the manhole while it is open. One or more red flags shall be placed on each side of the manhole (about five feet out therefrom).

In case of emergency when trucks, autos, street signs, or flags are not available a man with a red flag must watch the manhole, continuously while it is open.

At night red lights shall be used instead of red flags.

Before Entering the Sewer

After installing protection against traffic as above described, the manhole cover may be removed.

Testing for Gas

The interior of the sewer must now be tested for the presence of gas by lowering a safety lamp into it. (Testing for presence of gas by lowering a lighted candle or lantern into the sewer, as was sometimes done in the past, is dangerous as the presence of combustible gas may be denoted by an explosion.) The safety lamp will avoid possibility of an explosion.

If the lamp goes out it shows insufficient oxygen. If the flame flares up, the height to which it flares shows the amount of inflammable gas present in the sewer.

Aeration of Sewer

If gas is present the sewer is aerated by opening one or more manholes above and below the manhole which is to be entered. It would be well to aerate the sewer in this manner before entering it even when testing does not show presence of gas, as there might be pockets of gas in the sewer which the aeration will remove.

This process of aeration may be hastened and considerably helped, in small sewers, by flushing out with water, and in larger sewers by the use of a mechanical blower.

If gas is still present this aeration should be allowed to proceed for a day or more until the gas is eliminated or until it is demonstrated that the gas cannot be thus eliminated.

Entering the Sewer When There Is No Gas

When no gas is found, or gas has been entirely eliminated, a ladder should be lowered into the manhole (either at this time or during the testing for gas) in every case where the sewer is so large that the step-irons built into the manhole do not reach the bottom.

Men may now enter the sewer and perform their work. The safety lamp should be hung adjacent to their work to indicate the recurrence of gas during their working period due to stirring up sludge on the bottom of the sewer or due to any other causes.

Two or more men should enter the sewer together and one or two men watch at the top of the manhole to aid and assist the men in the sewer.

Ropes may be attached to the men in the sewer leading up to the watchers on top. The use of ropes is not insisted upon (when there is no gas) as it is considered by many to impede the work.

No man must be allowed to leave the foot of the manhole, to enter the sewer without wearing a gas mask, if the presence of gas is shown or if the presence of gas is even suspected.

When Gas Is Present in the Sewer

When gas is detected in the sewer all men working therein must use gas masks.

The procedure is the same as described above, viz:

Two or more men should enter the sewer together and one or two men should watch at the top of the manhole to aid and assist the men in the sewer.

Ropes should be attached to the men in the sewer leading up to the men on top so that in case any are overcome they may be lifted out.

It may be noted here that if there are hose attachments to the gas masks, these hose lines may be specially made strong enough to lift the men out thereby doing away with the necessity of ropes. (Fire departments very often require this extra strength of the hose attached to gas masks.)

Instruction of the Men

The men should be instructed orally in the above procedure and regulations and also practically instructed, and the methods and use of the apparatus demonstrated to them within the sewer itself, until they become thoroughly proficient with the methods of procedure and use of the apparatus.

All foremen should take courses in first-aid and methods of resuscitation. All the men should also be encouraged to take these courses.

When the oxygen content of the atmosphere in the sewer is insufficient to warrant entering the sewer with perfect safety, the sewer is too dangerous to be worked in. If entrance under these dangerous conditions is absolutely necessary, then the sewer should be entered by men with oxygen tank equipment and these men should be experts in the handling of such equipment.

APPARATUS

Testing for Insufficient Oxygen or Presence of Gases

The Flame Safety Lamp

The Flame Safety Lamp is a lamp in which the flame is protected by a double, fine steel wire gauze covering.

To make a test the lamp is lowered into the atmosphere to be tested.

If the lamp goes out it shows insufficient oxygen. The lamp will go out in air containing 16% of oxygen. Man requires 12% of oxygen in the air to sustain life.

If the flame flares up, the height to which it flares shows the per cent of inflammable gas present.

Other more accurate instruments for detecting the presence of explosive gases are:

Burrell Methane Indicator.

Martienssen Methane Detector.

U. C. C. (Union Carbide Co.), Methane Detector.

Carbon Monoxide may be detected by the Iodine Pentoxide Indicator, a very accurate color test.

Carbon Monoxide can also be detected by small animals. Canaries are the best. Others are the mouse, chicken, small dog, pigeon, etc.

When gases are discovered to be present it is always necessary to use gas masks.

GAS MASKS

Type "D" Self-Rescue Respirator:

This is a very portable outfit, to be hung from the belt, or carried in the pocket.

It consists of a small can and a mouthpiece and nose clip. Chemicals

in the can remove gases. It is designed more particularly as protection against carbon monoxide. This respirator will protect a man for half an hour.

Type "N" Gas Mask

Has a face piece to protect the eyes, with a tube to a cannister containing chemicals, all supported by a harness. This gas mask protects the wearer from all gases, smoke and vapors but it requires that there be oxygen in the air (none of the chemicals furnish oxygen.) One can charge of chemicals will protect a man for two hours.

These gas masks must be used with a Flame Safety Lamp to warn when the oxygen is below life supporting quantity.

When the atmosphere is such that the flame safety lamp goes out, indicating lack of sufficient oxygen, this latter gas mask may be used with a hose attachment leading to the outside pure air. A man can breathe through a length of about 25 feet of hose. Longer than 25 feet requires a mechanical blower to force the air through the hose. The hose may have two or four branches so that that number of men can work at the same time from one main trunk hose line. About 150 feet is the maximum length of hose men can pull around with them and perform their work.

A rope is attached to the man, either to his belt or to a harness, so that if an accident occurs he can be rescued wtih the rope.

Self-Contained Oxygen Breathing Apparatus

This type must be used where there is little or no oxygen.

The makes most commonly in use are:

Gibbs Apparatus;
Paul Apparaus;
McCaa Apparatus;
Fleuss-Davis Apparatus.

All of these makes have compressed oxygen tanks, with hose to mouth and nose.

The eyes may be covered to protect them from gas. These forms of gas masks protect the wearer for a period of two hours if the wearer is working, and for a period of 15 hours if the wearer remains quiescent. Self contained oxygen breathing apparatus require trained men to operate them.

RESUSCITATION

When men are overcome with poison gases or lack of oxygen, they must be restored by means of manual methods of artificial respiration, followed by oxygen applied with an Oxygen Inhaler. The latter instrument requires a trained man to operate it.

In regard to equipping a city or small town with safety apparatus the process may be somewhat after the following procedure.

A more or less complete set of gas masks, oxygen breathing apparatus, and resuscitation apparatus should be built up for the Fire Department, for it is absolutely necessary in that department in order to save lives in time of conflagration.

Then this apparatus is available if needed for dangerous sewer conditions, whenever such conditions may occur. The sewer department

will then be protected during the time it is accumulating its own apparatus.

ACKNOWLEDGMENTS

We wish to acknowledge our indebtedness for facts and data concerning apparatus as described herein to the following:

Circulars Nos. 33, 34 and 35 of U. S. Department of Commerce. On "Advanced Mine Rescue Training," and also Circular No. 30 "Use of the Miner's Self-Rescuer," of the same Department, and to Mr. F. H. Ash in charge of the Safety Division, United States Bureau of Mines located at the University of California.

Also Mr. J. B. Jones of the Mine Safety Appliance Co., has contributed valuable information and literature.

Respectfully submitted,

T. F. EASTMAN, Chairman
Committee on Safety Regulations of the
California Sewage Works Association.
H. H. Reddick, Santa Paula, California
H. P. Cortelyou, Los Angeles, California
W. O. Costello, Sacramento, California
J. F. Byxbee, Palo Alto, California
A. B. Stuart, Healdsburg, California

DISCUSSION

Mr. Rawn: Inasmuch as this report is complete and contains all of the facts as they have been determined by the Committee, and because it will be published in its entirety in the C. S. W. A. Journal, the Chairman will entertain a motion for its acceptance without discussion.

Mr. Rantsma: I would like to suggest a little discussion.

Mr. Rawn: You will all be asked to review the Published Report and send in your recommendations to the Committee. However we will recognize Mr. Rantsma's request.

Mr. Rantsma: I read an article in the C. S. W. A. Journal, which gave me a little surprise, mentioning the use of gas masks, etc. This matter of working in sewer gases is not necessary. In the first place you cannot get men to wear gas masks, and in the second place there really is no need to use them. Some slight mention was made in the article of some sort of blowers. The idea struck me first: "Why take gas masks, put a rope on a man, put him into the sewer, and then drag him out after he is dead?" A small blower with a ¾ horsepower motor will clear that up. One minute after that motor starts you can clear the air of all gas. It seems important to pay more attention to getting rid of gases than to the equipment for fighting them. There is absolutely no necessity for working in gas filled sewers.

Mr. Eastman: It must be remembered that there is often gas in the sewer after a blower has been used and men must have gas masks.

Take for instance where sludge is deep. After you get into a sewer, gas forms quickly under such circumstances and while the sewer may be free of gas when you start in, a few minutes later it may filled.

Mr. Rantsma: This little blower which I mentioned costs about $135.00. It is a small price to pay to save men's lives. I will be glad to give you further information. It will render a sewer absolutely free of gas immediately. We had one manhole which the men had never been able to get into on account of gas. After one minute's use of the blower the air was perfectly clear and we used no other device except this little ¾ h.p. No. 5 Blower.

REPORT AND RECOMMENDATION ON THE AWARD OF MERIT FOR THE YEAR 1935

Early in September, 1935, the Committee on Award prepared a circular letter concerning the AWARD OF MERIT of the California Sewage Works Association for that year and a Form of Declaration of Entrance of Sewage Treatment Plants in Competition for the Award. These were mailed to all Clerks of Communities and Secretaries of Sanitary Districts in this State which were operating sewage treatment works. It was stipulated that no entries would be considered unless received on or prior to November 1.

In response to the circular letter, three Declarations of Entrance into competition for the award were returned. To each of these places a questionnaire was sent calling for certain detailed information concerning sewage treatment. It was requested that this information, together with photographs of the plant, records of plant operation, and other pertinent data be submitted to the Committee not later than April 1, 1936.

All three applicants for the award responded with excellent reports, perhaps the best in general that have ever been received by the Committee. Consideration was therefore given by the Committee to the relative and absolute merits of the three applicant plants.

Holding in review the five cardinal features announced as the basis of judgment in determining the award, namely: (1) intelligent and conscientious operation; (2) efficient results; (3) good appearance; (4) local support, interest and pride in the plant; and (5) excellence of design; all were worthy. It was especially difficult, all things considered, to determine the award as between the City of Palo Alto and the City of Whittier.

RECOMMENDATION

In view of all of the circumstances and conditions, however, the Committee is unanimous in its judgment that the AWARD OF MERIT for 1935 be made to the City of Palo Alto and that the treatment plant of the City of Whittier be given Honorable Mention.

Respectfully submitted:
E. A. REINKE
CHARLES GILMAN HYDE

WHITTIER SEWAGE DISPOSAL PLANT

By M. R. BOWEN*

The sewage disposal plant is situated about four miles south of the city on a 98-acre tract owned by the City of Whittier. The plant consists of 1 bar screen (hand cleaned), 1 rotary screen (mechanically cleaned), 2 Imhoff tanks, 2 trickling filters, 6 sludge drying beds, 1 pre-aeration tank and 1 chlorinator for disinfection.

Approximately one half of the effluent is used for the irrigation of alfalfa, the remainder runs into the creek and thence to the ocean. The sludge is dried and sold for fertilizer. The plant is operated by one operator at $125.00 per month, and one assistant at $120.00 per month. The total investment, exclusive of land, is about $160,000. The total operating cost, including labor power, supplies and miscellaneous, for the year 1935 was $7,546. The revenue from the rental of the farm and sale of sludge was approximately $2,000.

Daily records of residual chlorine in the effluent are kept between 9 a. m. and 5 p. m. Occasional bacteriological tests seem to indicate that a chlorine residual of 0.5 p.p.m. is sufficient to insure thorough disinfection, and the chlorinator is now being run with a view to keeping the readings at or above this amount. No daily record is kept of the amount of sewage treated, but readings are taken at intervals which show that the flow is approximately 1,200,000 g.p.d. No regular chlorine tests are taken at night as the small sewage flow keeps the residual tests well above the required amount. The present method of disposing of the effluent by irrigating alfalfa or allowing it to run down the creek does not seem to require more complete records than we are now keeping. The city has considered the possibility of using the effluent for watering garden vegetables, in which case more frequent and complicated tests would have to be made.

The plant was beautified in 1934 by clearing about 3 acres around plant, graveling and oiling 50,000 sq. ft. of roadway, setting out 100 trees and 600 shrubs and seeding 13,500 sq. ft. of lawn, and installation of 1,700 ft. of irrigating pipe and 1,400 ft. of wire fence.

The original plant was installed in about 1908, consisting of a septic tank, 19 ft. wide, 96 ft. long and 11 ft. deep. The tank was composed of a concrete floor and walls with a redwood roof and baffles. In 1923 a new plant was installed consisting of an Imhoff tank, sprinkling filters and sludge drying beds.

The growth of the city greatly exceeded population estimates due to the development of the Santa Fe Springs oil fields, and by 1925 the installation showed evidence of being overloaded. A fine rotary screen was installed to reduce the amount of solids entering the Imhoff tank but this did not improve operating conditions sufficiently, so in 1926-27 the city constructed a duplicate Imhoff tank and sprinkling filter.

Operating results were generally satisfactory as far as the quality of the effluent was concerned, but the rapid development of residence

*City Engineer, Whittier, California.

property near the plant made the matter of odor control and general appearance increasingly important. At the time of the original installation there was only one farmhouse within a half mile radius of the plant, but by 1932 three subdivisions had been laid out adjoining and overlooking the sewer farm and the closest house was within 700 ft. of the plant.

Complaints of obnoxious odors became more and more frequent and some of them seemed to be justified, so the city had an odor control survey made by Black & Veatch. The main sources of odors were the screens, the sludge elevating machinery, the disposal of screenings, the Imhoff tanks which were not too well cleaned, the sprinkling filters when in action, the land irrigated with water direct from the Imhoff tanks, and the creek into which the unused effluent was discharged. Screenings were disposed of by burying near the plant. The land around the plant had never been graded and various piles of debris left by previous contractors made the grounds generally unsightly in appearance.

Acting upon the recommendations of Black & Veatch the city increased the size of slots in the rotary screen to ½-in. to reduce the volume of screenings, and installed an incinerator to burn these creenings. A reinforced concrete tank was installed between the screening plant and the Imhoff tanks for pre-aeration and oil skimming. A pump house was built with space provided for future installation of chlorinating equipment. Pumps were installed so that the treated effluent could be used for irrigating the farm instead of sewage direct from the Imhoff tanks and another pump was installed for furnishing a good supply of water under high pressure for washing down the Imhoff tanks.

In 1934 under a C. W. A. Project, the area around the plant was thoroughly cleaned. Since that time the lawns and shrubbery have been well cared for and the growth of shrubbery and trees is rapidly improving the whole appearance of the plant.

In 1934 the State Department of Public Health recommended that the effluent be chlorinated due to the fact that it flowed through a number of dairy farms on its way to the ocean, and one Wallace & Tiernan Chlorinating unit was installed.

The various improvements described have improved the operation and appearance of the plant to such an extent that complaints have been eliminated and the City sewer farm is a credit to the community.

POMONA ACTIVATED SLUDGE PLANT

By F. C. Froehde*

The Tri-City Disposal Plant was constructed in 1926 by the cities of Claremont, La Verne and Pomona. It was put into operation in May 1926 and has been in operation for approximately 10 years.

The plant treats sewage from three cities, Claremont, Le Verne and Pomona as well as sewage from the Pacific Colony, a state institution at Spadra, California; a total contributing population estimated at 17,500.

The operating scheme of the treatment involves preliminary settling in Imhoff tanks, thence treatment by the activated sludge process with re-areation of return sludge, thence settling in Dorr equipped clarifiers and chlorination of the effluent. In April, 1933, separate sludge digesters were added to this system.

During the first year's operation of the plant an average of 671,700 gallons of sewage per day was treated. This flow was gradually increased until an average of 1,166,000 gallons per day was treated in 1935.

The average preliminary settling period was 55 minutes with a minimum of 30 minutes.

Activated sludge was returned to the mixing channel at the rate of 500 gallons per minute and the average mixing period was 3 minutes with a minimum of 2 minutes.

The average areation period was 8.3 hours with a minimum of 5.5 hours. The average amount of air used was 1.8 cubic feet per gallon of sewage and 1.1 cubic feet per gallon of sewage and sludge. The minimum amount of air was 0.95 cubic feet per gallon of sewage and 0.71 cubic feet per gallon of sewage and sludge.

The average final settling period was 2.7 hours with a minimum of 1.5 hours.

The final effluent is given an overdose of chlorine of approximately 4 p.p.m.

Considerable paper mill waste finds its way into the sewerage system although all of the paper mill waste is now contracted for by a mutual irrigation company which pumps the waste into their irrigation lines. At times their pumps fail them, with the result that the mill waste is then dumped into the sewer lines. This necessitates a considerable increase in the amount of air to be used to treat the sewage.

We billed the paper mill for the added amount of power used to operate the blowers for the increased air consumption.

The paper mill felt very much aggrieved at the action of the engineering department in billing said paper mill for the treating of their waste and addressed a communication to the city council asking the city to assume the entire charge for treating their waste but promising that no more mill waste would be discharged into that sewerage system.

The city council agreed to absorb the charge provided that the paper

*City Engineer, Pomona, California.

mill either refrain from discharging mill waste into the sewerage system or pay for added cost of treating said mill waste.

The final effluent from the Tri-City disposal plant is sold to the North Side Water Company of Walnut which in turn sells it to ranchers in the Walnut district where it is used for irrigation on walnut groves, avocado groves and citrus groves.

Since the citrus packing houses started up this season we have been troubled with the dumping of concentrated boron solution into the sewerage system.

(Quoting from U. S. D. A. Bulletin No. 264*):

"In attempting to arrive at a correct understanding of the boron problem in southern California, it became necessary to decide whether the injury was due chiefly to boron as an original constituent of the soil of certain areas or as a constituent received in the fertilizer or the irrigation water. The present indications are that by far the larger part of the injury is due to boron carried in the irrigation water. Such injury was first identified (11) as the result of the use for irrigation of waste water from a citrus packing house where borax was used in the wash water for cleaning the fruit. The investigation of the conditions in a number of localities where boron injury has been found has led to the conclusion that, while some cases of injury may be traced to the use of fertilizer containing boron and while others may be due to the occurrence of boron in the soil as the result of natural causes, the great majority of cases are the result of the use of irrigation water in which salts of boron are carried in solution.

"In the investigations that have followed the discovery of this connection it has been found that boron is present in measurable quantities in all of the natural waters that have been examined, except in waters coming directly from high mountains and derived chiefly from melting snow. In other words, boron appears to be a normal constituent of the salts found in the percolating waters of southern California. It occurs usually in low concentrations of the order of 0.1 to 0.3 p.p.m., which is equivalent approximately to a solution of 2.5 to 7.5 pounds of borax in an acre-foot of water. In situations where crops showed boron injury the boron content of the irrigation water was found to be much higher, frequently more than 1 p.p.m. and occasionally as much as 7 or 8 p.p.m.

"Kelley and Brown (11, p. 455) reported on two samples of soil solution, obtained by the displacement method, in which they found 6.0 and 6.5 p.p.m. of boron. These soils were from lemon groves where the trees showed definite injury and where the investigators found 1 p.p.m. of boron in the irrigation water.

"In giving the present opinion as to the critical boron concentration in irrigation water and soil solution the writers have assumed a ratio between them of 1 to 8. . . . Of these factors, time is, of course, an important one. If, for example, irrigation water containing 0.6 p.p.m. of boron be applied to a tract of new land, it might take 10 years of

Note: *"Boron in Irrigation Waters" by Carl S. Scofield, Principal Agriculturist in Charge, and L. V. Wilcox, Associate Agronomist of the Division of Western Irrigation Agriculture, Bureau of Plant Industry. (Technical Bulletin No. 264, United States Department of Agriculture, November, 1931.)

irrigation to accumulate enough boron in the soil solution to be injurious to the more sensitive crops.

"In presenting their views as to these critical concentrations of boron the writers have indicated merely what conditions they have found in orchards of lemons and walnuts in southern California where evidences of boron injury were apparent. They do not wish to condemn as unfit for use every water supply that contains more than 0.5 p.p.m. of boron, any more than they would condemn as too salty any supply that contained more than 175 p.p.m. of chloride. But they do believe that when irrigation water contains more than these proportions of either element it should be regarded as possibly injurious to such sensitive crops as lemons and walnuts in situations where the root zone can not be leached occasionally.

"It is a matter of common observation that the evidences of boron injury are more striking in lemon and walnut trees that are not well cared for than in those groves where good cultural methods are followed. . . . There can be no doubt that where the boron content of the water supply is at or near the critical concentration, trees that are well fertilized and cared for show less evidence of boron injury and produce very much better yields than trees that are neglected. But these differences can not be traced definitely to any one factor, either of cultivation, irrigation, pest control, or fertilization. It might be added that no practical method has yet been found to remove from irrigation water the small quantity of boron that is sufficient to cause crop injury."

Between January 6th, 1936 and January 26th the final effluent showed boron contents of from 0.57 parts per million to 6 parts per million.

We were informed by the U. S. Dept. of Agriculture that water containing boron in excess of one part per million was highly detrimental to walnut, citrus and avocado trees. On January 29, 1936 the packing houses of Claremont, La Verne and Pomona were asked to cooperate in making the effluent fit for irrigation purposes by refraining from dumping the boron solutions into the sewerage system. In February a composite sample of effluent taken over a period of seven days showed a boron content of 0.75 parts per million but in March a composite sample taken over a period of seven days but at a different time of the month than the sample taken in February showed 11.5 parts per million.

On April 7, 1936 the city council passed an ordinance, No. 754, making it "Unlawful to permit any tank or other receptacle containing boron, soda or other solutions which will render the sewage water unfit for irrigation purposes, to be connected with the city sewer by means of pipes or any other connection whatsoever."

The ordinance subjects the offender to a fine of $500.00 for each day's violation.

We trust that it will not become necessary for us to enforce the ordinance.

Operating costs for 1935 were as follows:

Salary (Supt.)	$1.800.00
Gas (Supt. house)	56.86
Light and Power	3,689.54
Chlorine Gas	601.31
Gasoline and Oil	62.23
Telephone	33.45
County Taxes	28.16
Hardware	45.07
Supplies	208.96
Miscellaneous	29.67
Total	$6,555.25

Cost of treatment per million gallons	$ 15.60

Revenue for 1935 as follows:

North Side Water Company for effluent	$ 900.00
State of California, treatment of Pacific Colony sewage	97.00
Kellogg Supply Co., for sludge	658.00
Claremont and La Verne for treatment	1,450.00
Total	$3,105.00

The amount due from the North Side Water Company for effluent delivered in 1935 was $5,965.00 Had this amount been paid in full our plant would have been self supporting as far as the operating expenses were concerned. However the North Side Water Company only uses approximately ¼ of the effluent from the plant, wasting the balance in the San Jose Creek.

In the year 1932 which was the last year the North Side Water Company made any payments in full we received $4,748.00 for effluent.

The City Council has under consideration at the present time a new contract which will reduce the rates charged for effluent to one half the present rates which the North Side Water Company feels it has the ability to pay. This will reduce our income for effluent to approximately $3,000.00 per year.

Taken as a whole our plant has functioned quite satisfactorily and as general conditions improve throughout the country we believe we will approach the time when we may be able to operate our disposal plant at a profit.

DISCUSSION

Mr. Gray: What legal foundation is there for keeping boron compounds and plain sodium compounds out of the sewer by ordinance?

Mr. Froehde: I do not know. We have had good success so far, but, as I said, I do not think we will have to enforce the ordinance. There might be some technicality there that would prevent its enforcement. Those who contribute these wastes to the system must share in the

cost of disposal and their share is reduced insofar as we receive money for effluent in sludge. Receipts last year reduced our operation costs to $4 per m.g. Inasmuch as they have to pay the bill for operating the plant, they are all interested in keeping anything out of the system which would entail additional expense. As you gather from what I read from the Government Bulletin, boron is injurious to various kinds of citrus trees. A few years ago I had a little experience with avocado trees and know that they are highly sensitive to boron.

ONTARIO SEWAGE DISPOSAL PLANT

Report given orally by MR. AUSTIN BURT, City Service Manager:

I regret that we have been unable to put our data in typewritten form at this time.

There are several features about the Ontario Plant which may interest you. I will ask Mr. Ely to complete the report by a resumé of his experience as plant operator.

The Ontario Plant was placed in operation in July, 1935. At that time we were suffering from the industrial wastes problem. The General Electric Hotpoint factory was contributing chromic acid. I took the matter up with them and they denied it. After a complete survey we determined that it **must** be coming from this source. Through the courtesy of the Los Angeles County Sanitation Districts, Mr. Pomeroy was loaned to us for one month. He showed the General Electric people that they could save a lot of money by salvaging that chromic acid—as much as $500 a year. So you can imagine we aren't getting any more chromic acid in our plant at this time.

In studying the question of the disposal of effluent, we had an opportunity of disposing to one of the large irrigating companies, which looked fine. However, in working out the details it involved the use of a booster pump costing about $1,500 a year to operate. Mr. Pomeroy suggested that the waste product from the Exchange Orange Products Co. plant here might be suitable for making gas, and so for six weeks I sent the garbage truck to the orange plant, loaded it up and took the waste to the treatment plant where it was pumped into the digester. By doing this we increased the flow of gas from 18,000 to 41,000 cu. ft. per day, which was sufficient to operate the engine. The officials were satisfied that it would not upset the operation of the plant in any way. It was estimated that we could save about $1,200 a year by running a pipe to the orange plant and piping the pulp directly to our plant. The same plan might be worked using garbage. The BTU value of gas normally is 640. The orange pulp cut it to 550, but this did no harm—only required readjustment of the carburetor. We will now hear from Mr. Ely:

Mr. Ely: After we started last fall we didn't seed our plant at all. The consequence was that we accumulated a large amount of solids in the digester and then had a beautiful case of foaming for about six weeks, and reached a gas production of 60,000 cu. ft. per day. The foaming didn't interfere with operation of the engine, only required adjustment of the carburetor to take care of variations in the quality of the gas. At present the pH in the digester is about 7.5 to 7.6.

Some of the operating statistics are:

February (1936)—Total of 26,635,000 gal. sewage treated, using average of 1.9 cu. ft. of air per gallon. Electric Power bill—$1.78 per million gallons.

March—25,000,000 gal.—average of 1.89 cu. ft. of air per gallon. Electric Power bill—$1.72 per million gallons.

Dissolved oxygen in effluent: February 4.59 p.p.m., March 4.56 p.p.m., April (to 19th) 4.68 p.p.m.

Relative stability: February 97%, March 93%.

Average B. O. D.:

	February	March
Raw	261	207
Effluent	7.3	12.8
Per Cent Reduction	97	94

Mr. Burt: After the engine had run seven months the manufacturers took it down to see what effect sewage gases had upon it. They found it in practically perfect condition; some valves were slightly pitted, but not abnormally so.

COLTON SEWAGE DISPOSAL PLANT

By EZRA WEST*

The Colton sewage disposal plant was designed by the Currie Engineering Company of San Bernardino. This plant was built under the Public Works Administration, the Government making an outright grant of 30% of the construction cost. The construction contract was awarded to the Meyers Brothers of Los Angeles, amounting to $37,440.91.

Activated sludge was chosen as the type of treatment for two reasons: (1) the low installation cost, and (2) activated sludge would not require as much pumping. The plant is designed for a future population of 10,000, the present population being approximately 8,500.

The primary clarifier provides a 45 minute detention period on 200% of the average daily flow. The aeration and re-aeration tanks are designed on a basis of six hours detention of 125% of the average daily flow. The secondary clarifier provides a 2½ hour retention period on the average daily flow.

*City Electrician and Plant Operator.

The air is furnished by either of two Root-Connersville Blowers. One blower having a constant speed motor, and the other one a variable speed motor.

This plant was put into operation in June 1935. In starting the plant no attempt was made to seed the sewage, however, a flock developed and a clear effluent was produced in three days. This flock was very light colored, but settled well.

The operation of the plant was very good until the municipal plunge was opened, at which time the flow amounted to one million and a quarter gallons a day, this was of course, beyond the capacity of the plant and it was impossible to hold the sludge. The overflow from the plunge has now been diverted to another outlet, and we do not anticipate any trouble this summer.

Some trouble was experienced last fall from the waste and residue from the winery. Nothing has been done about this to date, however, we hope to have this trouble cleared up in the near future.

In the latter part of June and the first part of July some trouble was experienced from foaming in the digestion tank, the tank was emptied and refilled, as soon as we accumulated enough gas we started the heater and have kept the digester tank at an even temperature all winter.

Due to the fact that we had some difficulty with the integrator on the flow meter, we do not have an accurate total flow for the ten month period, however the flow is estimated to average about 500,000 gallons per day, or 152,500,000 gallons since the plant has been in operation.

The cost of labor is $1,824.00 or $12.00 per million gallons. The electrical energy for the ten month period amounted to $1,135.07 or $7.45 per million gallons.

Our average cost per month for the nine months of this fiscal year is $337.27.

The plant is equipped with pumps furnished by the Chicago Pump Co. The Scru-Feed pump used at the primary clarifier has given very good service.

All motors were furnished by the Sterling Electric Co. and are controlled by a Diamond E switchboard. The secondary clarifier was equipped by the Dorr Co.

The chlorine is controlled by a Wallace-Tiernan Chlorinator. A small Fairbanks-Morse pumping unit supplies water pumped from the secondary clarifier. We intend to drill a well in the near future, at which time we will use this unit to furnish clear water for the chlorinator and other purposes.

DISCUSSION

Mr. Rawn: Mr. Malloy, I for one, and think the others, too, would

like an explanation of that clear and sparkling effluent which we saw at the Colton plant.

Mr. Malloy: It isn't always just as clear as that. At times it is quite turbid and unstable but it is interesting to note that many times with low relative stability it is sparkling clear.

Mr. Currie: One big trouble has been the disposal of the overflow liquor from the digesters.

Mr. Rawn: Do you put it back in the aeration tank influent or in the raw sewage ahead of the sedimentation tanks?

Mr. Currie: Both places. It makes no difference, we have plenty of trouble anyway.

Mr. Rawn: It has been suggested that the extremely clear effluent is the result of lime water from the hills.

Mr. Currie: I cannot say about that.

Mr. Rawn: They say that is what made Green River Whiskey good and it might work the same way in your plant. What is the strength of the sewage? What is the designed capacity and period of detention?

Mr. Currie: The detention period is 6 hours. 600,000 gallons daily is the designed capacity. We have no tests available on the influent or effluent strength nor figures on the B. O. D. or D. O.

Mr. Rawn: What is the flow now?

Mr. Currie: Approximately 500,000 g.p.d.

Mr. Rawn: Then it is close to capacity now?

Mr. Currie: Yes, I think so. About 100 flush tanks in the city of Colton are all open.

Mr. Rawn: Is there dissolved oxygen in incoming sewage?

Mr. Currie: Undoubtedly there is.

Mr. Reinke: What is the tributary population?

Mr. Currie: About 8500. Some of the industries have opened up and there has been a considerable growth in population. At the time the plant was designed the population was approximately 5500.

RECENT INNOVATIONS IN SLUDGE DEHYDRATION AND INCINERATION

By WM. B. SENSEMAN*

This talk is listed in our program as "Recent Innovations in Sludge Dehydration and Incineration." The "recent" must be emphasized. Although only old and proven principles are involved, the application to sewage disposal is so new that data which might be given covering operations and costs in detail can do no more than suggest the possibilities. On the other hand, we hope that a review of the development will hold your interest and give you a rather clear idea of the possibilities of this new approach to the sludge-disposal problem.

The development originated with a firm manufacturing pulverizers and catering largely to the non-metallic mineral industry. For fifty years or more, pulverizers have been manufactured in which the pulverized material is handled in an air system. The air is used for separating fine material from coarse and for conveying the fines or finished product to bins or packer.

Figure No. 1 illustrates a typical pulverizer of the air-separation type. It consists of an adjustable feed mechanism; adjacent thereto a pulverizing chamber; a section, not clearly shown, used for fineness control; and a fan. The material enters through the feeder, is pulverized, passes on to the fan when ground to required fineness, and from the fan is blown to the cyclone collector, where the material is dropped through the discharge valve at the bottom and the relatively clean air from the top of the cyclone is returned direct to the mill or, as illustrated, is passed through a second cyclone, with or without the auxiliary fan shown.

In conventional pulverizing operations of this character, the system operates in a closed circuit with, theoretically, no intake or discharge of air. In practice, air does leak in on the section side of the system. It is introduced with the feed, if in no other way. Obviously, such air as leaks in must be vented, hence the vent illustrated.

After perhaps forty years of operation along this line it occurred to a number of operators, more or less simultaneously, that if hot air instead of air at atmospheric temperature could be used, a drying of the material being pulverized could be effected. The only additional equipment necessary was the supply of hot gas. It was then that the furnace and duct, shown in Fig. 1, for introducing the hot furnace gas into the mill system, was provided. In other respects, the system remains the same as when used for pulverizing only, except for such corrections as must be made in the air system for handling and venting the additional gas flow as represented by the furnace gas and water vapor.

This system ideally lends itself to drying. In every dryer, means must be provided to convey the heat to the material, to expose as much drying surface as possible, and to remove the vapor from the particle surface as rapidly as is possible. In a system such as this, the pulver-

*Pacific Coast Manager, Dryer & Incinerator Division, Combustion Engineering Co., Inc.



Fig. 1—Typical pulverizer of the air-separation type

izing action permits the maximum of surface exposure, the same pulverizing action in the drying medium gives a highly intimate contact, and the same violent agitation is an excellent means of removing the steam film from the particle surface. It has been named "Flash Drying"; and it is. The average time material remains in the circuit is less than twenty seconds. In that time it is dried, pulverized if desired, and delivered to storage.

Numerous types of pulverizers equipped with air separation lend themselves, to some degree, to this method of flash drying. When

selecting a unit upon which to attempt the drying of materials containing a high percentage of moisture, the pulverizer illustrated was selected. It is well suited for the purpose, as can be seen by a study of a cross-section as shown in Fig. 2. The bearings are outside the

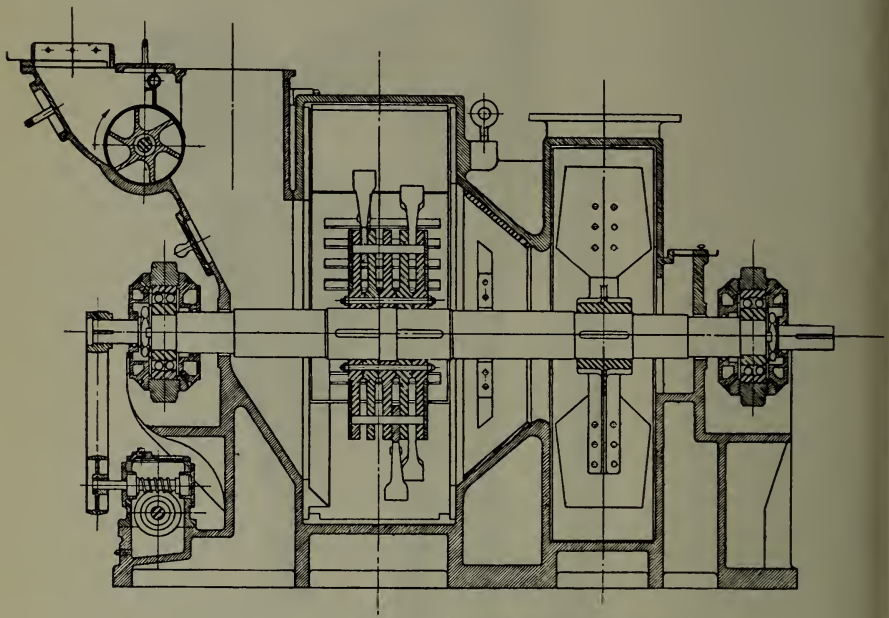


Fig. 2—Pulverizer with revolving swing hammers

mill and can be water-jacketed. The grinding is done by means of revolving swing hammers. When moisture in the material is so high that the material is in the form of a mud or slurry, the first effect of the hammer action is to atomize, hence the atomization of the mud or the pulverizing of a solid material gives the same desired result: the exposure of a large drying surface and a violent intimate mixture of the material and the gaseous drying medium.

With minor variations in detail and none in principle, this system was successfully adapted to many problems. Clay with 57% moisture, diatomaceous earth with 45%, milk albumen with 60%, were successfully dried. Gypsum and copper sulphate have been treated for removal of combined water; and coal, for burning in pulverized form, is now quite universally prepared in this manner.

With the development at this stage, Mr. Bailey of the Exchange Orange Products Company, suggested the drying of cooked orange pulp. The orange, both pulp and peel, with the juice extracted, is being successfully dried on conventional types of dryers, notably the rotary, but the pulped material, cooked during the distillation of oil, presented a problem that had not been solved.

After some preliminary experimental work, an installation was made in Ontario. As you who visited the plant today could see for yourselves, it is still an experimental unit installed as cheaply as possible. To attempt the work with the least possible cost was dictated by the nature of the experiment, the lack of a developed market for the dried material, and changing market conditions influencing the methods of producing essential oils.

Fig. 3 shows a flow sheet of the operation which you witnessed this morning at the plant of the Exchange Orange Products Company.

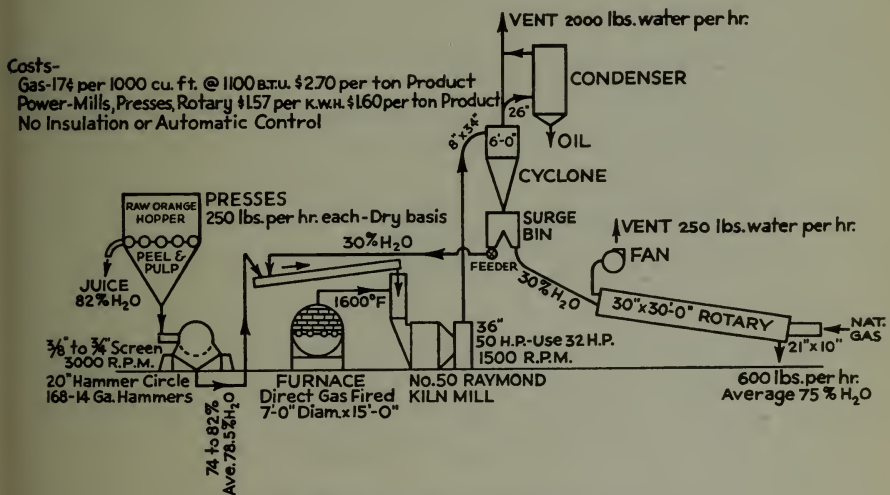


Fig. 3—Flow sheet at Exchange Orange Products Co. plant

Time does not permit of a review of the many things which we found by experience we could not do. I shall tell only of the final results and the reasons for them.

It was found necessary to mix dried, or partially dried, material with the wet in order to keep it from sticking and burning in the Flash Dryer.

It was found that the Flash Dryer was greatly handicapped if obliged to pulverize as well as dry, hence the hammer mill, already in place for proper pulping of the material previous to oil distillation, was used for pulverizing.

It was also found impossible to thoroughly dry an organic material such as this in the twenty seconds or less available in the Flash Dryer; particularly, since a finely ground product was not desired. So we pressed into service a rotary dryer previously used in attempts to dry the material.

Referring again to Fig. 3, the operation is as follows: Pulp and peel, after juice extraction, is put through a hammer mill, mixed with partially-dried material from the Flash Dryer, the mixture fed to the Flash Dryer, and the resultant product, approximately 30% moisture, finished on the rotary dryer. It represents a satisfactory and economical solution of a difficult problem. Both Flash Dryer and Rotary Dryer failed utterly to dry this particular cooked pulp. The combination of the two machines worked out very nicely. For the Flash Dryer it may be said that this experience definitely proved that material could be dried to only 30% moisture; and this knowledge is valuable in connection with sewage-sludge disposal, as will be pointed out later.

It may be well to explain that when a pulverizer, of the type illustrated in Fig. 1 and 2, is used as a pulverizer, the usual equipment consists of hammers 2½ in. wide across the face, with a clearance between the hammer and the shell of ⅜ in. operating at a speed of 1800 r.p.m. As a flash dryer, where actually the only function of the revolving parts is for violent agitation, the machine which you saw this morning is equipped with one-half the usual complement of hammers, they are ¼ in. wide instead of 2½ in., there is a 3 in. clearance between the hammers and the shell instead of ⅜ in. and the speed is 1200 r.p.m. instead of 1800. The result is that practically all the power used is that required by the fan.

On the basis of this experience here in Ontario, a method of drying and incinerating sewage sludge was proposed to the Chicago Sanitary District. After further experimental work, particularly with the burning of the sludge containing 25% to 30% water, an installation was made as shown in Fig. 4. This is quite different from the installation you saw this morning, hence a few explanations.

Although the apparent discoloration of the orange pulp in the drying process is positively not due to the temperatures used within the Flash Dryer, it is a fact that the dried pulp contains specks of charcoal. Temperatures are not reduced in order to eliminate this burning of the pulp, for burnt orange has neither an unpleasant odor nor taste. A little charcoal is certainly not harmful in a stock food, and obviously maximum capacity of the Flash Dryer is obtained with a relatively high inlet temperature.

For the same reason, maximum capacity, high inlet temperatures were desirable in the drying of sewage sludge, but here the necessity for positive odor control was fully recognized, hence the installation as shown in Fig. 4. It is predicated upon what is believed to be a proven fact: that if the temperature of all the vented gas from sludge-drying or incinerating is raised to 1200° F., odors will be eliminated. Obviously, venting gases at 1200° F. means an appreciable loss of heat, therefore, the plan as shown includes provisions for the recovery of this heat.

The furnace gas, raised to a temperature of 1600° F. or more, is vented to the atmosphere from the incinerator. The only treatment of the gas subsequent to the burning of the odors with the 1600° temperature, is to recover heat by means of heat exchangers (No. 1 and

No. 2 preheaters) and the elimination of fly ash by means of a cyclone illustrated as an ash trap.

The raw sludge, after mixing with a portion of the partially-dried material, is fed to the Flash Dryer, along with preheated air at 1200° or more from preheater No. 1. The vented gas from the cyclone, con-

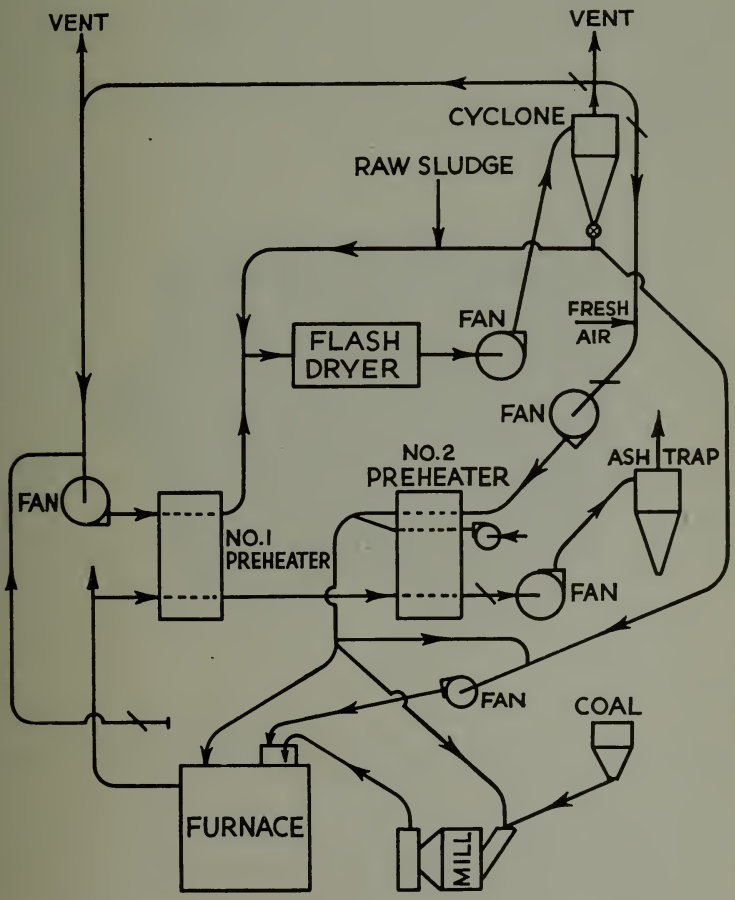


Fig. 4—Flow sheet for drying sewage sludge with positive odor control.

sisting of air and water vapor at a temperature of about 265°, together with such additional air as is needed for combustion purposes, is passed through preheater No. 2, where it is raised to 600°. This gas from preheater No. 2, air and water vapor at 600°, is then split three ways: As much as is needed for the burning of the 25%-moisture sludge, is fed to the incinerator along with sludge, where the sludge is

burned in suspension; a second portion is fed to a pulverizer for burning such coal as may be needed as auxiliary fuel; and the balance is fed back through the incinerator, to be raised to 1800° for odor elimination before being vented through the preheaters to the atmosphere.

Fig. No. 5 shows the type of heat exchanger used. A regenerative type. The hot gases pass through the revolving elements, thus giving up heat. Air passes through the elements in the opposite direction as the elements revolve, hence pick up the heat. On the Calumet Station of the Chicago Sanitary District, just starting operations, these heaters are guaranteed to deliver air continuously at a temperature of 1600° and at 1800° for lengthy periods of time.

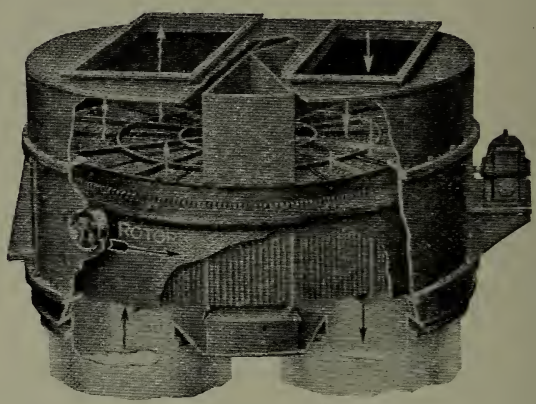


Fig. 5—Heat exchanger

The installation, as shown in Fig. 4, was made by the Chicago Sanitary District at the West Side Treatment Works, Stickney, Illinois. Three Flash Dryers were installed, duplicates of the one you saw in operation this morning. The design called for the handling of 2000 lbs. dry solids per hour, when drying and incinerating filter cake from activated sludge containing 80% moisture as it leaves the filter. This, in round figures, means the evaporation of from 7000 to 8000 lbs. water per hour. To give a clear mental picture of the size of the operation it might be well to add, the capacity is approximately twice that of the normal load handled by the Pasadena plant which we visited yesterday.

It was operated for months. The difficulties involved were mechanical troubles due in part to inexperience and, in greater degree, to temporary, hence cheap, construction.

After months of operation, as described, the Advisory Board appointed by the Public Works Administration to supervise expenditures of the Chicago Sanitary District officially approved of this method of sludge disposal and plans went forward for a permanent plant at the Calumet station. A drying unit of such size as previously used, was entirely too small in view of the magnitude of the work.

Experiment also showed this type to be poorly adapted to construction in large sizes; therefore, after a further period of development, the three original Flash Dryers were replaced with a single unit of new design.

This new design consists essentially of a series of bar cages, revolving between stationary cages of like construction. Material and hot gas enter through the center; the mixing of gas and material and disintegrating of material takes place as both material and gases pass out between the bars. There are no problems involved in building this machine in large sizes and experience proved it did not have the same tendency to plaster material on the casing, which the original machines did, hence much less dried material must be returned to the feed in order to properly condition the feed. Three of these units have been installed in the Calumet plant. The design and guarantees call for the operation of two units—the third is a spare—for a capacity of 40 tons dry solids per day. There is sufficient margin of safety in all calculations that the builders fully expect a capacity of 80 tons dry solids per day with all three units in operation.

That progress was made is well illustrated by a few figures:

	June 1934	May 1935
Coal used per ton Dry Solids	735 lbs.	160 lbs.
Over-all Efficiency	35%	45% (April 49%)
Power Cost per ton Dry Solids @ 0.8 cents per kwh	$4.00	$1.70
Sludge burned per Hour	1360 lbs.	1760 lbs. (the limit of the filter)

Power costs include both filtering and drying and incineration, the filtering operation accounting for one-third of the total.

Fig. 6 is a layout of the Calumet Plant. It is much more simple than the original experiment at the West Side Plant and yet deviates in no way from the practice established and proved there.

One heat exchanger is being used in place of the original two, and the auxiliary fuel equipment, if any, has no place in this system. Fuel can be fed to the furnace in any manner desired and handled in conventional ways as concerns combustion air supply, without regard for the drying system.

The big difference between this and the West Side Plant is that here the operation is in a vapor cycle. Vapor-laden gases, as vented from the cyclone, pick up heat as they pass through the heat exchanger, then return to the Flash Dryer. Gas and vapor are vented through the furnace and heat exchanger to atmosphere only in an amount equal to the water in the sludge plus combustion gases. With this system it has been found that since the drying is done in an atmosphere of

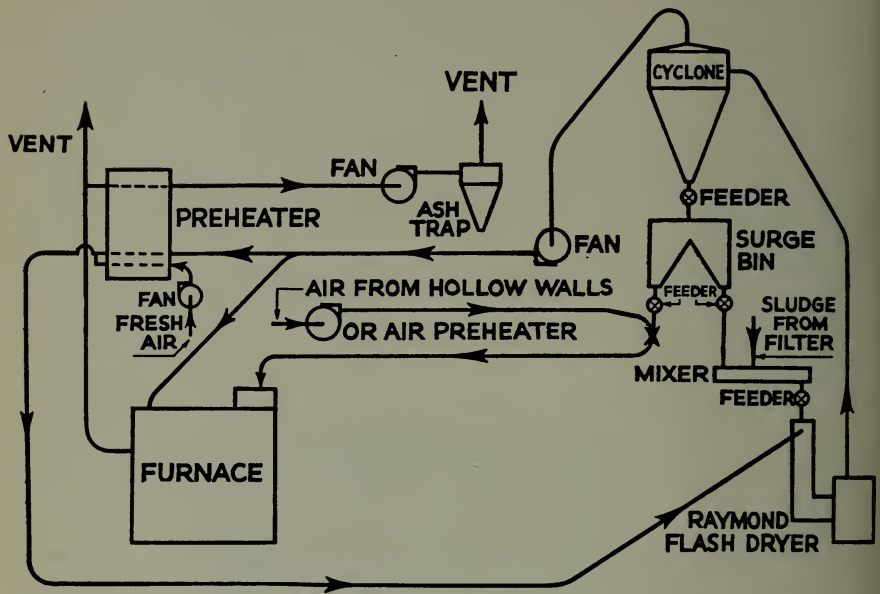


Fig. 6—Layout of the Calumet plant

practically all superheated steam, the sludge can be brought to complete dryness if desired, without danger of burning or over-heating.

If fertilizer is desired, it may be drawn from the surge bin. Temperature control will deliver it at any desired moisture up to 30%. If a moisture above 30% is desired, anything between 30% and 50% can be taken from the feeder below the mixer. If fertilizer is not wanted, the sludge can be used as a substitute for the fuel otherwise required.

Thus you have a picture of the development to date. For the moment, the sponsor's chief interest is in the practical application of the idea.

This new plant at the Calumet Works of the Sanitary District of Chicago is completed and ready for operation. Sludge can be burned or used as fertilizer. With the experience gained at the West Side Plant, as a basis for design and arrangement, substantial savings in power are anticipated, and the over-all guaranteed efficiency will mean the use of no auxiliary fuel when the sludge is being burned. I hesitate to give you the design calculations only because actual operating data will be available in so short a time.

An excellent description of this Calumet project as a whole, including a drawing of a cross-section of the drying and incinerating installation, appears in the Jan. 23, 1936 issue of Engineering News-Record.

This article, entitled "Sewage-Sludge Incineration Introduced at Calumet" is by Mr. William A. Dundas, Mechanical Engineer, Sanitary District of Chicago.

The arrangement of parts, in a system such as this, offers a good test of the ingenuity of the designing engineers. An idea of the possibilities is well illustrated by plans already made for a plant having an evaporating capacity of 20,000 pounds water per hour, which, with 83%-moisture sludge, means 60 tons dry solids per day. This installation consists of a simple furnace and two Flash Drying units. It can be adequately housed in a building 52-ft. high with floor space 28 ft. x 42 ft.

THE BEACHES OF CALIFORNIA AND THEIR PROTECTION

By GEORGE HJELTE*

The fame of California as a desirable place of residence is usually ascribed to the climate, but of no less importance in contributing to its fame are two great recreational assets, the forests and the beaches. California is abundantly endowed with both. We have only recently become aware, however, of the importance of these recreational assets and have taken steps to protect them from destruction and to preserve them in their natural beauty and usefulness from many destructive forces. It would be difficult to determine which of the two is the greater recreational asset, particularly in California since both the forests and the beaches contribute to the pleasure and healthful recreation of millions of people each year.

The extent to which the beaches of Southern California are used for recreation is amazing. Records of the departments of the City and County governments of Los Angeles responsible for the administration of public beaches show that no less than twenty-five million visits are made to the publicly-owned beaches in this area in a single year. On July 4, 1928, the Citizens' Committee of Parks, Playgrounds, and Beaches, which was then making a very extensive park and recreation survey of the area of Metropolitan Los Angeles, made a careful count of the number of people who attended the beaches seeking recreation on that warm summer day. The total recorded was three hundred fifty-three thousand, from which it may be inferred that on that day one person out of every eight in the Metropolitan Area sought and found recreation upon the beaches. Any facility which contributes so extensively to the pleasure and to the health of the people is of the utmost vital importance.

*Superintendent of Recreation, City of Los Angeles, California.

It is fortunate indeed that we have become aware in California of the value of the public beaches to our community in time to preserve some of them for the recreation of the people. Our awareness of their importance is due to the fact that improved transportation in the last two decades has made the beaches much more accessible and therefore much more useful than formerly. New York City, whose population stands in much greater need of beaches for recreation purposes became aware of the value of beaches only too late, for out of eighteen hundred miles of water front in Metropolitan New York, there are only sixteen miles useful and available for public recreation. A minimum reasonable allotment of beach for the recreation of the New York population would more nearly approximate ninety-five miles. Greater Los Angeles on the other hand has twenty-six miles of beach for a population roughly only one-fourth that of Greater New York, and of the twenty-six miles, approximately fifteen miles are in public ownership.

In speaking of the public ownership of beaches, it is necessary to distinguish between the ownership of the lands which are washed by the tides and the uplands which adjoin the tidelands. In the State of California, as in all coastal states with noteworthy exceptions, the tidelands are owned in fee by the State. California by legislative enactments has granted to municipalities such tidelands as lie within the municipal boundaries to be held in trust generally for purposes of commerce and navigation. Although these tidelands are frequently of more beneficial use in connection with recreation than commerce and navigation, the grants of the State Legislature do not specify recreation as one of the purposes for which the grants have been made. This has not so far constituted a serious obstacle or handicap, but it may in the future since the question of the right of municipalities to encroach upon the tidelands with roads, piers, and other structures distinctly for recreational uses may be seriously brought into the question.

The uplands adjoining the ocean on the entire coast of California are in private ownership except where by grant, deed, dedication, or gift, portions of these uplands have been given to the State, counties, or cities. The popular notion that beaches are all publicly owned is therefore a delusion since beaches consisting both of uplands and tidelands and the right of access to the tidelands may be wholly defeated by the fencing of privately owned lands immediately adjoining them.

Nearly all of the upland beaches owned by the cities, counties and the State of California have been acquired by dedication or donation. The establishment of an attractive public beach has demonstrated itself to be an important factor in the upbuilding of any seashore community, which has given those who laid out such communities and the sub-dividers involved in such development ample incentive for dedicating or donating for public recreation use some very attractive portions of the ocean strand. The cities, counties and the State have expended some funds, usually derived from the sale of bonds, for

the acquisition of beaches, but this program has not been an extensive one. There is a vital need in California at the present time for the acquisition of more beaches for public use, and as the need becomes more apparent and as economic conditions improve, doubtless there will arise movements directed toward this end.

It is interesting to note that the thing that makes a beach attractive and valuable as a recreation area is sand. As the trees of the forest are the surface covering which makes the forest areas attractive to recreation seekers, so the sands of the ocean shore are the feature which enhances the use of the shore for recreation. The sands like the trees are not immutable and indestructible since there are a number of natural and artificial forces which continually operate to diminish the amount of sand on the beaches and in some cases to even destroy very attractive beaches over a period of time.

The supply of sand on the beaches is derived from the uplands and river-washed back country. The natural erosion of these areas which takes place provides a continual supply of beach sand which when it reaches the tidelands is carried slowly but consistently down shore in the direction in which the shore currents travel. This sand distributed by the action of the waves is carried in some quantity in suspension in the water which in turn is transported from northwest to southeast by the prevailing coastwise current in Southern California. Thus there is a slowly moving current of sand down the coast which disappears into submarine canyons at any location where the slope of the abutting shore is steep, causing a depth of water immediately offshore. In these depths the sand falls to the bottom where the movement of sand is nil or imperceptible. Were it not for the continual replenishment of the supply of sand from the eroded uplands, the natural forces would tend to diminish the upland continuously and in some coastal areas, notably those in the vicinity of New Jersey, such a condition is noticeable.

Fires and floods have very noticeable effects upon the amount of sand which is available for beach building. Forest and grass fires which denude the coastal ranges of trees and other surface covering enhance the amount of water run off and the transportation of debris and sand from these areas to the coast. Recent fires in the Malibu and Santa Monica mountains will undoubtedly result in upbuilding of beaches adjoining these areas. A contrary effect is apparent when intensive development of the adjoining uplands takes place. Subdivisions which result in the substitution of paved for natural drainage channels and coverage of part of the area by buildings and cultivated plots reduce the wash of debris and sand from these areas.

Noticing the movement of sand down the Santa Monica Bay coast, some upland owners in recent years have constructed groins at right angles to the shore to intercept the flow of sand. The result of such experiments has been a considerable accretion on the windward side of these groins and a corresponding diminution of sand on the beaches to the leeward. The construction of breakwaters offshore, notably those at Santa Barbara, Santa Monica, and Venice, has had a similar

effect. The quiet water created between the breakwaters and the shore has caused the sand carried in the currents to be deposited in these areas which otherwise would have been carried by the current down the coast and would have been available for preserving the hydrographic balance there. The amount of sand collected by such structures is most impressive. Measured records of sand accretion caused by the Santa Monica Breakwater showed that approximately four hundred thousand cubic yards of sand were accumulated in the area between the breakwater and the upland in the course of one year.

Considerable difficulty has been encountered in California in controlling these factors. One of the difficulties arises from the fact that until recently no permit has been required for the construction of groins or breakwaters into the tidelands except a permit from the United States Government Engineer. The granting of this permit however has been based only upon the possible effect that such structures might have on commerce and navigation. No investigation as to the effect upon tideland ownership or upon adjoining beaches has been called for by the United States Government or other political subdivisions.

Another difficulty has arisen in determining the ownership of artificially accrued beach lands. While the law of the State of California is clear that natural accretions belong to the upland owners and that artificial accretions belong to the State, the difficulty of determining exactly what constitutes artificial accretions has been serious. This difficulty arises because of the lack of competent and recorded surveys indicating the natural location of the mean high tide line over a period of years. It is of the utmost importance that frequent surveys be made of the high tide line along our entire California coast in order that the essential facts in the adjudication of suits involving tidelands might be available.

Pollution of the beaches is a menace to this great recreational resources no less important than the matters already mentioned. Cities located on the seacoast as well as those located on large rivers have for decades habitually disposed of their sewage into the ocean and river waters. As population has increased along the seashore of California the effect of ocean water pollution in the use of the beaches for recreation has been very serious. Considerable areas of very attractive beach have been rendered unusable by sewage pollution. The importance of this problem is now being recognized by many groups and by none with more concern than the sewage works and sanitary engineers who have been agitating more modern and scientific means of sewage treatment and disposal, not without considerable success in the State of California.

Oil pollution is also proving to be a serious problem particularly in Southern California where the oil industry is one of the largest local industries. The seriousness of oil pollution is evident to all who go to the beaches during the summer time, for it is impossible to walk barefooted upon the sands of the Southern California beaches without staining one's feet with oil. Occasional films of oil are found upon the

surface of the waters rendering these waters unusable for bathing until the oil film is caried away. The destruction to fish and bird life is also considerable and a recognition of this fact has resulted in fairly effective legislation in California for the prevention of oil pollution of coastal waters.

The pollution of ocean waters by oil is traceable to four general sources: First, the bilge pumping of oil tankers; second, the careless and accidental waste of crude and refined oil from the drilling and pipe line equipment situated in the oil fields along the coast; third, industrial and domestic wastes of oil of all kinds into the sewage systems; and fourth, the series of oil springs located offshore opposite Redondo Beach, Manhattan Beach, Santa Barbara, and perhaps other places.

Bilge pumping has been fairly well controlled in California through the effective administration of State and Federal laws prohibiting such pumping within the three-mile limit. Effective also in the prevention of this pollution has been the whole hearted cooperation of the larger oil companies whose own regulations are most severe in relation to this matter.

Pollution from oil field operations has been quite effectively controlled in recent years largely through the efficient administration of local beach authorities and the State Fish and Game Commission. Game Wardens are most vigilant on the California coast and have been very effective in enforcing laws governing these matters. Public opinion has forced upon the oil drilling companies more care and vigilance upon their part in preventing unnecessary pollution.

Similar cooperation has been forthcoming from officials in charge of sewage disposal systems. The disposition of oils into the systems is governed quite generally by local legislation, but because of the innumerable points at which such pollution originates, these laws are very difficult to enforce adequately. Some education of the general public concerning this subject is desirable in order that more effective cooperation may be had from the public.

Recent investigation has revealed that the natural oil springs offshore are probably the most serious source of beach pollution at present. These springs are located on an earthquake fault running generally from southeast to northwest and cutting through Huntington Beach, Palos Verdes, and west of Santa Barbara. At various points along the approximate line of this fault quantities of oil can be seen rising to the surface. The prevalence of an oil film on the ocean waters is a matter of common knowledge among navigators, and even as early as the sixteenth century this condition was known to the Spanish explorers. Guides for navigators published in the early part of the nineteenth century contained specific reference to such oil springs, notably off the Santa Barbara coast, and navigators were known to have verified their location on the ocean by the presence of an oil film on the water and sometimes by the smell.

The control of oil pollution of the receation beaches is a matter that is challenging the several governmental agencies that are responsible

for beach administration in the Southern California area. Eternal vigilance is necessary on the part of these agencies in order that law violations might be detected promptly and flagrant cases prosecuted. These agencies feel, however, that considerable research is necessary to determine the exact source of pollution, whether the same is from the oil springs, bilge pumping, sewage waste, or oil field disposal. Such research is now being conducted under the auspices of the Beach Coordinating Committee of Southern California in cooperation with the State Fish and Game Commission.

The beaches of California may be thought of as serving the people who reside along the seacoast, but upon more careful reflection it is evident that the beaches render valuable service to the people of the entire nation, the vast majority of whom do not live along the seacoast but who nevertheless look forward to the eventual opportunity of sojourning on the seacoast and enjoying the benefits that pertain thereto. The coastal communities therefore may take the view that they hold the beaches in trust for the benefit of the entire nation and that there devolves upon them the responsibility of protecting this great natural heritage of the American people and preserving their beaches not only from natural forces which may tend to destroy their usefulness, but also from artificial works and commercial and private exploitation which reduce their ultimate usefulness.

EXPERIENCES WITH DIGESTER FOAMING

By HARRY E. SCHLENZ*

One can appreciate the wide scope of successful operation of sewage treatment plants, when consideration is given to some of the problems which are encountered, regardless of whether the treatment process involves digestion in Imhoff Tanks or in separate chambers. Successful methods in one locality may be failures in others.

The outstanding features of Imhoff and separate digestion tanks is their temperamental nature, especially during the first months of operation. It appears that, either properly or improperly; we classify most of our digestion troubles under the heading of "Foaming"—therefore a discussion of the subject must necessarily cover a fairly wide field.

The New York Department of Health in their manual on the "Operation and Control of Sewage Treatment Plants" (19) give the following definition:—

" 'Foaming' is a term used to describe the condition which develops in Imhoff or separate digestion tanks where froth, gas and scum rise in the gas vents or scum compartment and may be carried over into the sedimentation compartment or flow out of the tank."

Accompanying Fig. 5 shows a good example of foaming in the Imhoff Tanks at Decatur, Illinois, while Figs. 2, 3 and 4 show the evidences of foaming in separate digestion tanks.

Some of the possible causes of "Foaming" which have been advanced, and which will be discussed individually, are as follows:

1. Excessive loadings of raw solids in relation to digesting solids in the tank.
2. Increased activity causing rapid formation of gas and "boiling" action.
3. Objectionable organisms in the sewage and in solids settled from the sewage.
4. Character of the sewage such as the predominance of objectionable products such as laundry, cannery, brewery wastes, etc.
5. Departures of the pH from normal.
6. Marked viscosity of the liquid or scum, and also the mechanical action of gas attempting to escape through scum having a high surface tension.
7. Character of the raw solids loading.
8. Restricted area of gas vents.

It is evident that some of the above causes may overlap or be definitely related, or that the "Experiences of Plant Operators" which will be related may even come under causes different than the writer has selected.

1. Excessive Loadings of Raw Solids in Relation to Digesting Solids in the Tank.

Rudolfs has suggested in a Report of the New Jersey Experiment

*Vice President, Pacific Flush Tank Co.

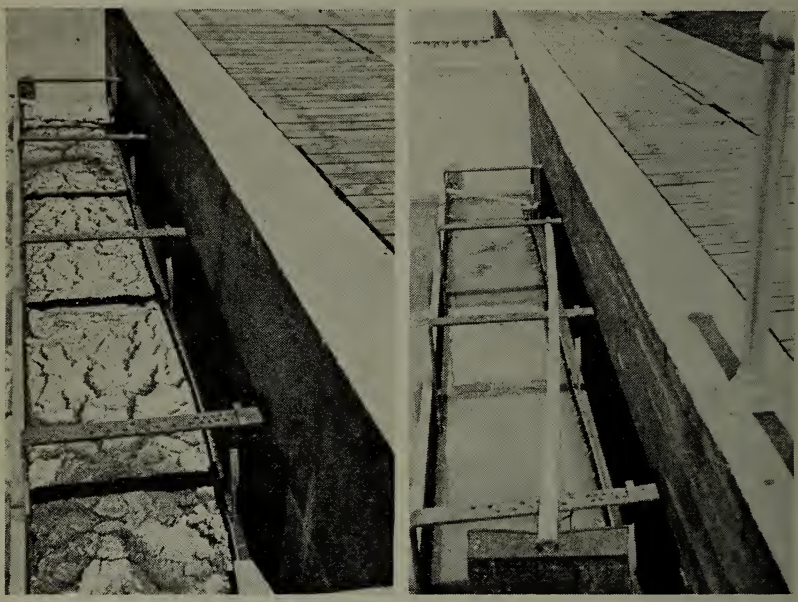


Fig. 1-A (left)—Scum on flow channel of Imhoff tank No. 4, Urbana, Champaign, Ill.

Fig. 1-B (right)—Freedom from scum on flow channel of tank No. 1, Urbana, Champaign, Ill.



Fig. 2—Foam oozing from heated digester at San Antonio, Texas, 1935.



Fig. 3—Nature of foam forced from covered digester, San Antonio, Texas

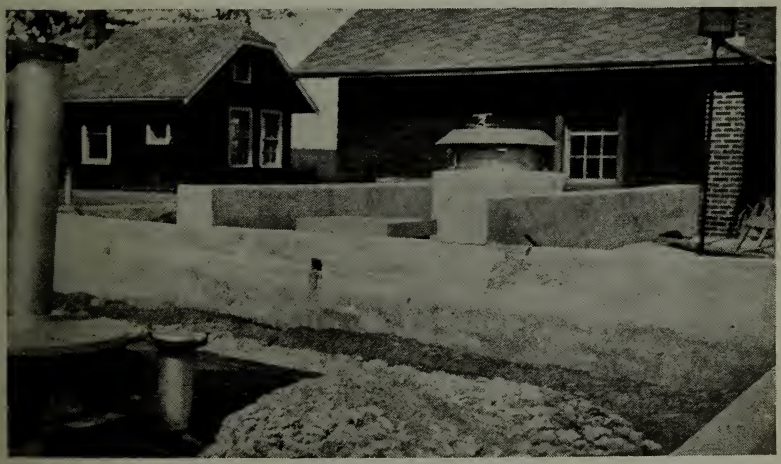


Fig. 4—Frothy material on heated digester at Marshfield, Wisconsin, 1934.

Station, 1926, that the digestion of sewage solids may be divided into three stages or periods, for consideration of the difference in the nature of the digestion. It will be noted that if there is too great a volume of solids undergoing the first two periods of digestion, as would happen with an excessive raw solids loading, that there will be a tendency for acid conditions to prevail.



Fig. 5—A real case of foaming in Imhoff tanks at Decatur, Illinois, in 1930.

Downes (4)* indicates that the production of organic acids in the first stages of digestion will cause an inhibiting effect, bringing digestion to a halt.

It appears that we encounter most of our "foaming" troubles when a tank is started up. This is generally the cause with modern treated separate digestion tanks at least—indicating that digestion is retarded due either to the producing of this inhibiting condition or the lack of a condition which will promote digestion.

It is the writers contention that only actively digesting material may be counted upon in balancing the acid tendencies of raw solids and thus promote digestion.

Hatfield (23) relates an experience at Decatur, Illinois (See Fig. 5) where as plant superintendent he had shut down his Imhoff Tanks for three months to install gas vent covers. A liberal amount of digested sludge with a volatile solids content of 25% to 30% was retained in the tanks for seeding purposes. However, when raw solids were added the tanks foamed just as though they were being initially started.

Since digested sludge occupies valuable space it should be removed frequently to allow capacity for actively digesting material—in fact the strictest routine should be adhered to in withdrawing sludge so that the proper balance is maintained. Too great a withdrawal at any one time will upset the balance.

Correspondence with C. C. Larson, operator and chemist at Springfield, Illinois, indicates that on August 1st, 1935 they were operating two out of their six tanks as primary units receiving raw solids, and within three months they began to have violent "foaming" troubles.

*Numbers refer to bibliography at end of article.

The pH was not bad, but the assumption was that these tanks were being loaded too heavily with raw solids, so on January 1st, 1936, another tank was cut in as a primary making three tanks for the receiving of raw solids. This apparently eliminated the "foaming."

2. Increased Activity Causing Rapid Formation of Gas and "Boiling" Action.

It is the writer's opinion that in the majority of cases "Foaming" is but the outward manifestation of a very active tank. It may be caused by the layover of solids capable of undergoing active digestion, and which solids begin to digest due to an increase in temperature or other conditions favorable to digestion.

At Fort Atkinson, Wisconsin, the sewage treatment plant was started up in cold weather (as invariably is the case) with the result that solids were added to a digester the contents of which remained at approximately 40° F. for a prolonged period. With the approach of warm weather a pronounced "foaming" took place.

The outward appearance in the form of "Foaming" is caused by the lifting of the scum on the surface of the tank by the gas which is attempting to be released from the digesting mass.

Coulter (34) indicates that "foaming" occurs only in connection with very vigorous gasification, and is especially prevalent with restricted gas vent.

Imhoff (5) states that he has observed that foaming may take place after the ripening period and without acid fermentation, and Rawn (10) states that although factors in connection with "foaming" in separate tanks under his observation have not been determined, acidity apparently is of no importance.

Further observations of the experiences of others indicate that two types of foaming are encountered—namely, foaming under acid and under alkaline conditions. Riker (26) found at Princeton, New Jersey, that in a separate digestion tank, "foaming" took place when the pH was over 8.0.

Welch (25) relating foaming experiences at Flint, Michigan, in 1933 stated that the action was limited to the scum layer of the Imhoff Tanks, where the pH was 7.0, and that there was no sign of the disturbance of the lower sludge zone. In former years the "foaming" disturbed the sludge throughout the tanks.

Hatfield (23) indicates that on one occasion at Decatur, Illinois, the pH of his Imhoff tanks was 6.4 to 6.6 before tanks began to foam, and that it remained this low for three to four months after liming and after "foaming" had ceased. Curves plotted for two years at this plant showed no relationship between pH and "foaming" when observed in the liquor above the sludge. Titratable acidities of the sludge liquor at Decatur, in general, were low when the tanks were not foaming, and high when foaming, but sometimes this did not hold. A normal increase above normal acidity indicated possible foaming, but not a certainty.

Decatur's normal phenolphthalein acidity has been between 200 and 500 p.p.m. and to bromthymol blue 150 to 400 p.p.m., expressed

as $CaCO_3$. "Foaming" has taken place with acidities as low as 150 to 200 p.p.m., and have run as high as 1,100 p.p.m. during foaming. There have also been periods with no "foaming" with acidities as high as 400 to 600 p.p.m.

Hatfield found his best correlation with alkalinities to methyl orange expressed as $CaCO_3$ indicating that some have always been abnormally high during "foaming." Normal alkalinities have run less than 1,000 p.p.m. just before foaming, and during foaming have run as high as 2,500 p.p.m. He further states that there have been exceptions with "foaming" occurring with low alkalinities, but that a reasonably good correlation may be shown between high alkalinities and "foaming."

3. Objectionable Organisms in the Sewage and in the Solids Settled from Same.

It has been suggested by some observations that certain organisms may be responsible for "foaming" tendencies, with indications that responsibility for acid production in the early stages of digestion might be laid to organisms of the B. coli group.

Cohen (1) states that "foaming" may be due "to abnormal physiochemical conditions of materials in gas vents in connection with a quantity and quality of gas resulting from certain predominating types of organisms or bacteria." Cohen forms the above opinion after success with the stopping of "foaming" at Lufkin, Texas (where the pH of the foam was from 7.0 to 8.9) by the application of chlorine to the raw sewage. A dosage of 20 p.p.m. was first tried with good results —the black liquor in the flow channels became white and milky due to the release of H_2S and the deposit of finely divided sulphur.

Liming of the same tanks was unsuccessful in stopping "foaming" and only gave temporary relief. Chlorine applied to the sludge compartment met with failure in stopping "foaming" similar to findings at Fort Worth and Dallas, Texas. Returning to a dosage of 6 p.p.m. of the raw sewage again gave good results, but a stoppage of the dosage to make repairs caused foaming to start again within ten days. It stopped again in twenty-four hours with the resumption of a 6 p.p.m. dosage. It was found that the dosage of chlorine could be reduced to 3 p.p.m. and be continued only for the period from 8:00 a.m. to 5:00 p.m.—dosage being based on the average flow for that period. The same results were verified at Breckenridge Texas, and Cohen's explanation was that the chlorine exerts a selective killing action on living organisms.

West (15) reports that in 1932 at the South Side Plant at Stockton, California continuous difficulty had been experienced with "foaming" which was accentuated during the canning seasons. Chlorination at 3.5 p.p.m. for sixteen hours per day carried out in one of two tanks showed a decided improvement within ten days. The dosage was increased to 4 p.p.m. on a basis of twenty-four hours per day with a noticeable improvement in the settling action also.

4. Character of the Sewage Such as the Predominance of Objectionable Products Such as Laundry, Cannery, Brewery Wastes, Etc.

Eddy (29) suggests that if the water supply is hard, insoluble soaps

may be formed, and if they constitute a substantial increment in the suspended solids of the sewage may favor the formation of foam and scum.

Trades wastes may increase the viscosity or surface tension of the liquid with possible tendencies in connection with "foaming" which will be discussed later. A stale sewage or one containing pickling wastes may promote an acid tendency and start "foaming."

5. Departures of pH from Normal.

It has been suggested that as a result of the lowering of pH, considerable CO_2 is produced when reacting with carbohydrates present.

Eddy (29) states that "perhaps certain kinds of action such as fermentation with production of large quantities of CO_2, does not as rapidly disintegrate, gasify and render soluble the coarser organic substances as other varieties of action. Therefore there may be an abnormal accumulation of scum-forming solids tending to overload the scum compartment, or to form gas-lifted masses in such quantities that excessive scum formation is inevitable.

Hatfield (23) finds that when digestion is normal the CO_2 content of the gas is less than 20%—between 20% and 25% conditions may be satisfactory—and during "foaming" the CO_2 content has been above 25% with a maximum of 33%.

6. Marked Viscosity of the Liquid or Scum and also the Mechanical Action of Gas Attempting to Escape Through Scum Having a High Surface Tension.

Coulter (35) states that from observation he has come to the conclusion that "foaming" and related difficulties arise from a combination of high viscosity of the liquid and the concentration of the escaping gases at the surface. He states that solids kept in constant and intimate contact with highly unstable organic matter undergoes vigorous decomposition and the liquid tends to take larger quantities of matter into solution and becomes viscous. When in contact with the rapid escape of gas at the surface this viscous liquid creates a foam. "Foaming" is somewhat analagous to "priming" or "foaming" in steam boilers where anything prevents the free escape of steam from the water, and the principal cause is believed to be an excess of dissolved matter which increases the surface tension of the liquid. Oil on the surface will also increase the surface tension and cause "foaming" or "priming."

Eddy (29) states that at some plants gas rising in the vents has produced a light voluminous foam, due to tenacious films enclosing the gas bubbles.

Dr. A. M. Buswell, an authority on colloids, according to recent correspondence on the subject, indicates that foam and scum are distinctly different conditions. Scum results merely from the rising of lighter material to the surface where, due to its own buoyancy, it lifts out of the liquid and becomes compact and dry. Foam, on the other hand, is due to the upward passage of gas bubbles through a liquid under such conditions that they do not break at the surface. Colloidal materials such as soap, etc., are always much more concentrated at

the surface of a bubble than they are in the body of a liquid. He goes on to say that the principal reason for a stable foam is that the film is more or less viscous so that it does not flow downward to such a degree that the remaining film becomes very thin and breaks.

Buswell further explains that "surface tension" has been wrongly considered as a determining factor in the stability of a foam, and that actually experiments have shown "surface tension" to have little to do with foam stability. The stability is due to a concentration of materials in the foam which cause it to be tough and viscous.

7. Character of Raw Solids Loading.

The return of humus sludge from a secondary settling tank may cause "foaming." This condition prevailed at Urbana-Champaign, Illinois. Recent correspondence with G. H. Radebaugh the plant superintendent indicates that to reduce "foaming" to a minimum, especially in the spring time, he returns humus from his secondary tank during the period of reduced flow at about 10 p.m. The humus goes into the influent channel feeding four Imhoff tanks, it being the idea to distribute the solids to all tanks equally. It was found, however, that tank No. 4, the flow channel of which is shown in Fig. 1-a, foamed while tank No. 1, the flow channel of which is shown in Fig. 1-b, did not foam. The light humus sludge had been carried to the end of the channel by the velocity of flow and loaded tank No. 4 more than the others. In 1930 Radebaugh (20) indicates that while 1380 yards (45 beds) of sludge were drawn, some 450 yards (15 beds) of scum were removed from his tanks.

The addition of a large quantity of grease from newly constructed grease separation tanks at Springfield, Illinois, caused violent "foaming" to take place. By carefully controlled loadings, however, the operator reports they are able to add the grease to the digesters.

8. Restricted Area of Gas Vents.

Coulter (35) states that foaming is intensified by small vents or vents restricted by relatively large amounts of scum, while Eddy (29) in comparing the relative operation of a number of Imhoff tanks states that "evidence is so meager and conflicting, that a final conclusion regarding the comparative merits of a small and a large proportion of gas vent area is not justified."

Mohr (30) suggests a modified Imhoff tank with a submerged flowing through compartment, giving the entire enlarged surface of the tank for scum. He states that the rising gas filled scum requires a certain area of surface to release the gas.

PROPHLYTICS AND REMEDIES FOR "FOAMING"

Operators are really more interested in what might be done to relieve "foaming" in a tank rather than what might cause it to take place. Although the writer has already indicated certain remedies, it might be well to outline those which have been suggested to relieve "foaming."

Care in Maintaining Proper Balance of Raw and Digesting Solids

Completely digested material should be removed to prevent using up space required for digestion. Sludge which is digested sufficiently should be removed frequently, but in small quantities.

M. W. Tatlock, plant superintendent at Dayton, Ohio, states that he obtains the best results with his Imhoff tanks when he keeps the sludge level up near the slots, drawing small quantities of sludge at frequent intervals. Hatfield (23) agrees with this procedure as long as the sludge which is retained in the tanks is still active, and not a lot of dead inert material.

Draw All Sludge from Tanks and Start Anew

Hatfield (23) recommends this procedure, stating that the sludge in a foaming tank is infected material and the sooner it is gone the better. The writer would question the feasibility of this procedure, except for an unusual situation.

Addition of Lime

We find a great divergence of opinion on the use of lime to eliminate foaming. Eddy (29) reports that the use of lime in the sludge compartment sometimes reduced and sometimes increased the tendency to foam. Walraven (12) states that liming was not effective at Springfield, Illinois, and Imhoff (5) also says liming is not so reliable.

Cleland (11) reports the addition of 200 lbs. of lime per million gallons of sewage to maintain a pH of 6.7 at State College, Pennsylvania. He also states that the addition of 55 lbs. of lime per 1000 gallons of sewage effected a reduction of 2 ft. in the scum layer during a foaming period.

Agar (18) reports aid in correcting a foaming condition by the addition of lime at the rate of 10 lbs. per 1000 population per day, adding it directly to the scum layer in the gas vents.

Hatfield (23) indicates that the addition of lime retarded foaming but did not stop it. One of his tanks receiving lime stopped foaming only a few days before an unlimed tank stopped foaming. He feels that the quantities of lime required are prohibitive when a large amount of sludge is present in the tanks.

Chlorination of Sewage

As stated in detail before, Cohen (1) reports marked success in stopping "foaming" with a dosage as low as 3 p.p.m. of chlorine added to the flow channel of an Imhoff tank during the period of from 8:00 a.m. to 5:00 p.m., while West (15) indicates the use of 4 p.p.m. during a twenty-four hour period.

Allow Tanks to Remain Idle Without Any Unnecessary Agitation

It has been suggested that a foaming tank should be taken out of service and allowed to rest. It would appear to be more feasible to keep the tank in service and accomplish the same result by lessening the loading.

Break Up Scum in Gas Vents by Mechanical Churning

This procedure has been tried in most cases but gives only temporary

relief by releasing entrained gas. It is very ineffective when consideration is given to the amount of labor expended.

Remove Scum from Gas Vents

Removing the scum may give relief, but it is an undesirable practice. Wilson (37) reports that 90 to 95 per cent of the scum at Bloomington, Illinois, is volatile matter and is readily digestible.

Saturation of Scum with Liquor

Hosing of the scum in the gas vents has been quite widely used as a means of breaking up the foam and releasing gas. Buswell suggests a more satisfactory scheme of saturating the foam or scum with liquor drawn from the clear portion of the digestion chamber, the theory being that the slow circulation of this liquor, which is more dilute than the foam, tends to reduce its viscosity and allows the entrained gas to be released. This method has been successfully used at Urbana-Champaign, Decatur and Bloomington, Illinois, plants.

Submergence of Scum

The submerging of scum as a positive way of causing the scum to become saturated with liquid in the tank, results in a lessening of the viscosity, as explained above, and releases the gas, allowing the solid material to sink to the bottom.

Heating of Contents at Start

In most cases "foaming" may be prevented in a digestion tank which is just being started up by bringing the contents of the tank up to optimum temperature by heating with an auxiliary means, so that digestion will be started, rather than to allow solids to lay over to undergo violent digestion at a later time, with possible "foaming."

In concluding we may say that a digestion tank seems to be able to take quite a good loading—but when it starts to kick up it must drop back a long ways on loading to recover.

Welch (25) likens a foaming tank to a boil—it must come to a head before subsiding.

Hatfield (23) states that a properly designed tank will give good results even when foaming as badly as shown in Fig. 5, as long as the flowing through chamber is properly baffled.

DISCUSSION

Mr. C. F. Tennant (Los Angeles Sanitation District): With due respect to the speaker, I wish to disagree with most of the remedial measures offered. Having tried most of them without success, I have become very skeptical. In our experience we have seen foaming occur at both high and low pH. During the operation of an experimental digestion unit of four stages, foaming never occurred in the first stage, usually in the second or third, and occasionally in the fourth. This experimental unit had 100,000 gallons capacity or more per stage, was unheated and entirely open at the top. The sludge in these open tanks has been known to rise as much as 3 ft. in twenty minutes and subside almost as rapidly. The cause for foaming was there before foaming

appeared, but what touched it off is unanswered. Restricted gas outlets may appear to cause foaming if they are of insufficient size to readily release the gas from an active tank.

Foaming is a very difficult thing for an operator to handle. Since the fundamental causes are not yet understood, effective remedies cannot be applied. But when foaming occurs the operator must do something and measures of relief must be resorted to, such as lowering the surface of the tank in case it has not been provided with sufficient head room to prevent overflow, hosing of the slots or, in the case of covered tanks, circulation of the liquor where top inlets are provided may afford some relief by mechanically breaking the foam.

Liming of the tanks has been tried by us without success. Spraying the surface of the foam with kerosene or gasoline to reduce the surface tension has also been tried without success. Adjustment of the sludge level in cases of severe foaming has appeared to have no bearing upon the situation. The normal scum of the tank in periods of excess foaming is so intimately mixed with the foam that it is difficult to say whether the action is in the scum itself or the mixing is a result of vigorous action from below. In the case of open top tanks, lawn sprinklers can be used to some advantage.

There is one point that has not been touched in this discussion and that is temperature. Both the experimental unit to which I refer and the permanent four stage digestion unit now in operation have experienced their worst periods of foaming at lower temperatures, usually between 70 and 75° F. The permanent digestion tanks now in use operated several years without foaming in excess of the head room provided. As the sewage flow has increased, the load placed upon the digestion tanks has reached a point where during the winter it is difficult to maintain the optimum digestion temperature of 85° F. Last winter with the temperature of the sludge around 70° F. serious foaming was experienced. I am strongly inclined to the belief that temperature is an influence.

Mr. R. A. Stevenson: In 1932 some experimental chlorination activities were carried out at the Stockton, California, plant. Three to four parts per million of chlorine were applied to the raw sewage at the entrance to the Imhoff tanks. There was an excessive amount of finely divided material in suspension, and the total chlorine demand was about 22 p.p.m. Immediately there was an improvement in the foaming condition with consequent clarification. The startling thing was the improved clarification of the sewage. Also, there was less gas action in the lower compartment. My theory, which seems to be substantiated, is that the chlorination of the organic particles destroyed their tenacious nature and the ability to form a tenacious film. You might ask Mr. Pomeroy if he can offer any further explanation.

Mr. Richard Pomeroy: Before answering Mr. Stevenson's question, I would like to make a few remarks on the subject of Mr. Schlenz' paper.

In discussing the theory of foaming, some mention was made of the surface tension and the viscosity of the sludge liquor. These factors

have very little effect on foaming. I am glad that Mr. Schlenz included the quotation from Dr. Buswell in his truly scientific explanation of the phenomenon. Certain colloidal materials or dissolved materials of high molecular weight tend to concentrate in the surface film—in the thousandth of an inch of the liquid nearest the surface. They thus form viscous films, which do not break, even though the viscosity of the body of the sludge or liquor may be low.

We need to distinguish between the actual condition of foaming and a state of the sludge favorable to the formation of foam. The sludge may have a composition favorable to foaming, but if the gas production is low and the bubbles have room to break or are broken mechanically, foaming may not manifest itself. In the digesters of the Los Angeles County Sanitation District the tanks are divided by baffle walls into separate bays. The composition of the sludge must be nearly the same in different bays, and yet sometimes one bay will foam while another does not. But when one bay or one tank foams, we know that at any moment another bay or tank may foam. The conclusion is that all of the sludge has a composition favorable to foaming, and only awaits the proper mechanical state. On the other hand, the gas production may be high and there may be a thick layer of floating scum and yet no foaming. I have seen scum with 16% of solids produce gas at the rate of 5 cu. ft. per day per cu. ft. of sludge, yet with no foaming.

If the sludge has a tendency to foam, breaking of the foam by mechanical means will give temporary relief, but this does not remedy the cause. The tendency to foam is probably caused by the nature and concentration of the colloids in the sludge liquor. In composition these colloids are so complex that we have little hope of identifying them by analytical methods. Their variable nature is probably determined by the types of micro-organisms which are active. We may expect that these in turn will be influenced by the seeding material and its proportion to the raw sludge, the composition of the sludge and liquor, the stage of digestion, and the temperature. Thus, it is to be expected that there would be some relationship between temperature and frequency of foaming trouble, as has been suggested by Mr. Tennant.

With regard to chlorination, if enough chlorine could be diffused through the sludge to affect the entire sludge body, it would probably have some effect on foaming, for better or for worse, either by affecting the micro-organisms or affecting the colloidal particles directly. Again, if chlorine is fed continuously to the sewage it would ultimately affect the composition of the sludge and the micro-organisms in the sludge. But it is hard to see how 3 or 4 p.p.m. of chlorine in the sewage could change the character of the whole sludge mass in one day. Maybe it does, or again maybe the apparent correlation quoted by Mr. Schlenz is accidental.

The tanks of the Los Angeles County Sanitation Districts were operated for four years without foaming trouble. The tanks did foam, but the free space between the sludge level and the cover, 6 ft. in the first stage and 4 ft. in successive stages, was enough to accommodate the foam. Then in February of this year we had a serious siege of foaming

in which the foam several times came clear to the top and filled the gas lines, or poured out of the port holes if we got the port holes open soon enough. Chemical analyses did not show any significant differences from previous results except that the sludge from the last stage was less advanced in digestion, presumably because of lower temperatures. This showed up in volatile organic acid figures running as high as 800 p.p.m. and bicarbonate figures down to 2700 p.p.m. as CO_2. It was thought that the trouble might be due to the fact that for seed sludge we were using this poorly digested sludge, which had had only eight to ten days' digestion at about 76°. Consequently, older sludge from the storage pit, about two weeks older than that from the digesters, was tried. Foaming subsided. Then in an attempt to determine if this represented a real correlation or an accident, we started seeding one of the two batteries of digesters from the pit and the other battery from its own last stage. We have been doing this for six weeks and have observed no difference in the behavior of the two batteries! Neither is foaming and both are digesting the sludge equally well. However, the sludge from the digesters used to seed the one battery is now better digested than was the case in February, so the original theory may be right, although there is nothing to prove it.

With regard to the ratios of new sludge to digested sludge, which Mr. Schlenz has stressed, it is significant that in our multi-stage digesters we get satisfactory operation by adding only one part of seed to four parts of raw sludge.

In view of the fact that there is no sure-fire way yet known to prevent sludge from occasionally getting in the mood to foam, it is of great importance that tanks be made to take care of the foam.

Mr. J. A. Smith (Consultant, Pasadena, California): I recall, as you perhaps all will, during childhood days, trying to make soap bubbles. It seems to me there is a very apt comparison there between soap bubbles and foaming such as we are now discussing.

My opinion is that grease is back of most of our foaming. The alkalinity of the water turns the grease into soap. Then we have the bacterial action to produce the gases to get the bubbles. Since we installed the grease removal tank at the Whittier Plant there have been no cases of foaming.

Mr. E. A. Reinke (California Department of Health, Berkeley, California): It seems we should hear some questions from the operators: What is the operator going to do? Occasionally you will find a duplicate sludge pump or a duplicate chlorinator, but rarely will you find a duplicate digester unit or Imhoff tank. Most of our experiences have been that where there is room enough you don't have trouble with foaming. One community placed digestion tanks in operation and had no difficulties for about three months, and then the tanks foamed all over. After considerable investigation we blamed it onto a little fish cannery and made them quit putting fish wastes into the sewer. Strangely enough the tanks foamed again the next year! As a result of further investigation we learned that all during those days of foaming there was a large winery on the outskirts of the town which had been hooked up to the

plant (without the knowledge or consent of the authorities). Well, the plant wasn't designed for a big winery.

Mr. F. S. Currie (Consultant, San Bernardino, California): The San Bernardino, California, plant was placed in operation in February and in June it foamed a great deal. We emptied the tanks and started them up again, and we haven't had any bad foaming since. Ontario, California, foamed when first put into operation. Colton, California, likewise. Most of the plants are put in operation in the winter time when temperatures are low. A big load is built up before digestion gets under way and that causes foaming.

Mr. Ely (Operator, Ontario, California, Plant): Last fall I had seven or eight different remedies given me for foaming and no two agreed. We started about the middle of July with no seed sludge. By the middle of September gas production was well started. Our normal gas production is 17,000 cu. ft. per day. By the middle of October the gas production was above this figure due to digestion of the accumulated sludge. Then we began to have foaming trouble. Our remedy was to open the outlet at the bottom of the digester tank and let the sludge go until scum stopped coming over the top. We worked this system for six weeks. We didn't drain a tank and didn't put in lime. I'd simply turn the valve every time and the sewer farm got it. At one time when I went to take the temperature I had to plumb down through 12 ft. of foam in the top of the tank to reach real sludge. We started in at a temperature of about 82°. When it was foaming well it was 93°. We reached a peak gas production of 60,000 cu. ft. of gas a day. The quality of the gas was reduced so we used as high as 15,000 cu. ft. in the engine instead of about 11,500 as at present. As the temperature and gas production receded, our foam receded. When the foaming stopped we turned on the city water and raised the tank so as not to lose the gas seal. We have had no foam since that time. In the winter we started out to see how much gas we could make by loading the tank with orange pulp, as you have heard. We raised the gas production to 45,000 cu. ft. per day—as high as it was during most of the foaming period—and the results were very satisfactory.

Outline Formulated by Dr. W. Rudolfs from Report of New Jersey Agr. Experimental Station—1926

DIGESTION OF FRESH SEWAGE SOLIDS

(Neither Well-Digested Sludge nor Lime Being Added)

I. PERIOD OF INTENSIVE ACID PRODUCTION

(a) **Materials Attacked**

1. Easily available carbohydrates (sugars, soluble starches, cellulose).
2. Soluble nitrogenous compounds.

(b) **Organisms Responsible:** B. coli group, spore-forming anaerobes.

(c) **Characteristics**

1. Increase in acidity.
2. Solids: gray, less than half on top.

3. Odors: putrefactive, H_2S.
4. Liquid: fairly clear to slightly turbid.
5. Slight coagulation of colloidal material with heat and alcohol.
6. Disappearance of protozoa.
7. Increasing B. O. D. values.

(d) **Products**
1. Organ acids, H_2S.
2. Gas: comparatively large volume with high precentage of CO_2 and N_2.
3. Acid carbonates.

(e) **pH range:** 6.8 to 5.1.

(f) **Results**
1. Reduction of colon organisms.
2. Retardation of proteolysis.

II. PERIOD OF ACID REGRESSION OR ACID DIGESTION

(a) **Materials Attacked**
1. Organic acids.
2. Nitrogenous compounds.

(b) **Organisms Responsible:** Not definitely determined.

(c) **Characteristics**
1. Prolongation of the low level of pH values followed by a slow rise.
2. Solids: gray to yellowish-brown, half to four-fifths at top.
3. Odors: H_2S, indol, onion (mercaptans).
4. Liquid: slightly turbid (milky) to yellow.
5. Some to considerable coagulation of colloidal material with heat and alcohol.
6. High B. O. D. values.

(d) **Products**
1. Gas: small volume, with decreasing percentage of CO_2 and N_2; hydrogen formed.
2. Ammonia compounds (amines, etc.)
3. Acid carbonates.

(e) **pH range:** 5.1 to 6.6 or 6.8.

(f) **Results**
1. Gradual rise of pH curve.
2. Acceleration of digestion.
3. Foaming.

III. PERIOD OF INTENSIVE DIGESTION OF MORE RESISTANT MATERIALS

(a) **Materials Attacked**
1. Nitrogenous materials.
 (a) Proteins.
 (b) Amino-acids, etc.
2. Ligno-cellulose (?)

(b) **Organisms Responsible:** Spore-forming anaerobes, and fat-splitting organisms.

(c) **Characteristics**
1. Decreased acidity.
2. Increased alkalinity.
3. Slowly rising pH curve.
4. Solids: dark brown to black, half to none at top.
5. Odors: odor associated with methane; tarry, rubber.
6. Liquid: slightly turbid to clear.
7. Some to no coagulation with heat, slight to no coagulation with alcohol.
8. Reappearance of protozoa.
9. Rapidly decreasing B. O. D. values.

(d) **Products**
1. Ammonia and other protein degradation products.
2. Organic acids.
3. Gas: large volume with high percentage of CH_4, low CO_2 and N_2, and no H_2.

(e) **pH range:** 6.9 to 7.4.

(f) **Results:** sludge stable enough for disposal.

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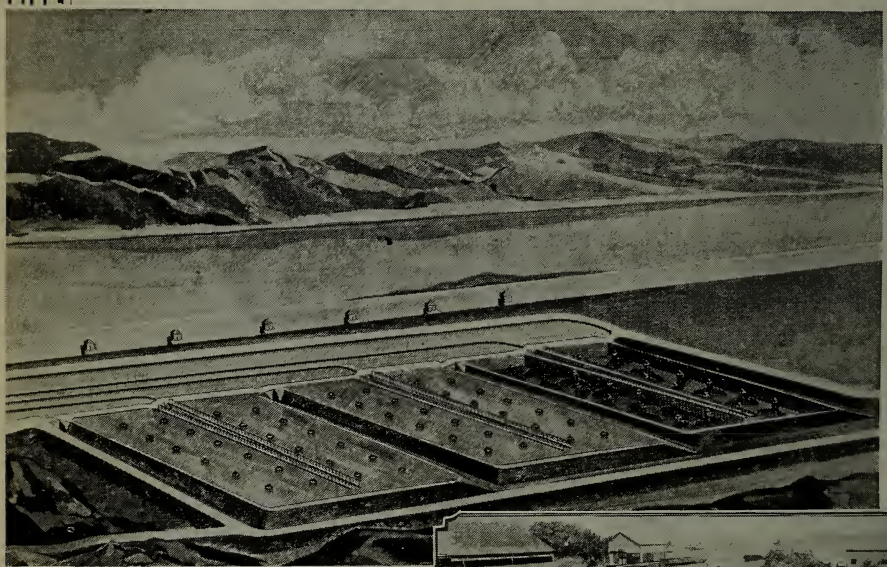
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CALIFORNIA SEWAGE WORKS JOURNAL

Official Publication of the California Sewage Works Association

Vol. IX :: 1937 :: No. 1

Minutes of the Ninth Annual Convention
at Santa Monica, California
September 11 and 12, 1936

•

State Finances

•

Sewage Disposal at Hyperion Plant

•

Sewage Disposal at Terminal Island Plant

•

Proposed Sewage Facilities for San Diego

•

Shifting the Trickling Filter Into High

•

Committee Reports



THREE MEN DEA
from H_2S

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First Vice-President

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Alexander Bell 171 Second St., San Francisco

Secretary-Treasurer

R. R. Ribal 701 City Hall, Oakland

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Published by CALIFORNIA SEWAGE WORKS ASSOCIATION

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Vol. IX 1937 No. 1

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NINTH ANNUAL CONVENTION

Santa Monica, September 10 and 11, 1936

PROGRAM

Thursday, September 10th

Morning

INSPECTION CARAVAN

9:00—Convene at Los Angeles City Hyperion Disposal Plant.
10:30—Arrive Los Angeles County Sanitation Districts' Plant, Harbor City.
11:30—Arrive Los Angeles County Sanitation Districts' Tunnel and Shaft.

Afternoon

12:30—Luncheon: Palm Gardens, White's Point.
1:30—Inspection of Ocean Outfall and South Portal of Tunnel.
3:00—Arrive Los Angeles City Terminal Island Disposal Plant.
4:00—Arrive Long Beach Disposal Plant.

Evening

5:30—Registration at Miramar Hotel, Santa Monica.
7:00—Dinner at Miramar Hotel.
Address by A. E. Stockburger, Director, Department of Finance, State of California.

Friday, September 11th

Morning

9:00—Meet with City Engineers and Street Superintendents' Section of the League of California Municipalities, Miramar Hotel.

Papers

"Proposed Changes and Improvements in Sewage Disposal at Hyperion Plant of Los Angeles City"—and comments on Terminal Island Work—H. G. Smith, Division Engineer, Bureau of Engineering, City of Los Angeles.
10:00—"Improvements to the Stockton Sewage Disposal Plant"—C. C. Kennedy, Consulting Engineer, San Francisco.
11:00—"Reconstruction of the Los Angeles County Sanitation Districts' Joint Disposal Plant and Construction of Sewage Disposal Tunnel and Ocean Outfall"—A. M. Rawn, Assistant Chief Engineer, Los Angeles County Sanitation Districts.

Afternoon

12:30—Luncheon at Miramar Hotel, Santa Monica.
1:30—Technical Session and Business Meeting, Miramar Hotel.

Papers

"Shifting the Trickling Filter into High"—Harry N. Jenks, Consulting Sanitary Engineer, Berkeley.
"Proposed Improvements in Sewage Facilities for San Diego—B. D. Phelps, Assistant City Engineer, San Diego.
3:00—Business Session: Reports of Committees and Discussion: Voluntary Licensing of and Schools for Disposal Plant Operators, and Safety Regulations.
4:00—Election of Officers: Adjournment.

Evening

7:00—Annual Banquet, League of California Municipalities—Casa Del Mar Club.

PROGRAM SPRING CONFERENCE
CALIFORNIA SEWAGE WORKS ASSOCIATION
STOCKTON, CALIF., APRIL 23-24, 1937

FRIDAY MORNING, APRIL 23.

There will be a tour of inspection to the Lodi Activated Sludge Plant where interesting electrical metering can be observed and to both Stockton Plants where recent construction will be nearing completion.

FRIDAY AFTERNOON, APRIL 23.

After a joint luncheon with the Stockton Engineers Club at the Hotel Clark, Conference Headquarters, the afternoon will be devoted to a technical session. There will be a discussion of the plants visited on the morning tour, a paper on "Electrical Metering at an Activated Sludge Plant," an Operator's Symposium on Mechanical Equipment," and a paper "Treatment of Effluents" by S. I. Zack who has had much experience with the subject and who is making the trip from New York City to be with us.

FRIDAY EVENING, APRIL 23.

You are promised an exceptional dinner meeting with a speaker; probably one who will tell us of the San Francisco-Oakland Bay Bridge, which should be of particular interest to those planning to cross the Bridge Saturday afternoon or evening. The Award Committee will report and the annual award will be made to the most meritorious treatment plant. A panel of members of the Association who have recently returned from extended trips will discuss and answer questions on Sewage Disposal in the Eastern part of the Country.

SATURDAY MORNING, APRIL 24.

The usual business of the Association including committee reports will open the session. A paper on the live subject of "Cannery Wastes" will follow the business meeting. For the second paper of the session we will hear about "Sewage Disposal in the Northwest" from Carl E. Green, Past President of Pacific Northwest Sewage Works Assn. The conference will close with a paper by R. E. Brown on "A Trip Through the Los Angeles Outfall."

SATURDAY AFTERNOON, APRIL 24.

The afternoon will be free for those members who desire to motor to Oakland and San Francisco to view the Bridge both by day and by night. Inspection trips to Tracy, Manteca, and other plants will be arranged for those not desiring to motor to the Bay Area.

MINUTES OF THE
NINTH ANNUAL CONVENTION
CALIFORNIA SEWAGE WORKS ASSOCIATION

At Santa Monica, on September 10 and 11, one hundred and twenty-five members participated in the 9th Annual Conference of the California Sewage Works Association which met with the League of California Municipalities.

Situated in the heart of the Los Angeles metropolitan area, Santa Monica proved an exceptionally satisfactory starting point for the association's customary inspection "caravan" on their first day of meeting. Proceeding from the convention city at 8:30 in the morning, members assembled at Los Angeles' extensive Hyperion Screening Incineration Works located on Santa Monica Bay. Following the inspection the group proceeded to the Joint Disposal Plant of the Los Angeles County Sanitation Districts which utilizes what is basically the activated sludge process and rapid multi-stage digestion tanks, through which solids pass in less than two weeks and from which gas is taken for power production.

Continuing, the caravan advanced to Camp No. 2 on the line of the 6.2-mile tunnel being constructed by the County Sanitation Districts to convey effluent from the joint disposal plant to the ocean outfall at White's Point. The group there were given the opportunity to see the tunnel construction, involving several innovations and new expedients.

Following luncheon in the Palm Gardens, adjacent to the location of the District's ocean outfall at White's Point, an inspection of the ocean pipe line and tunnel construction was made. After this the caravan proceeded to Los Angeles' new Terminal Island Treatment Works and thence to the screening and incineration plant of the city of Long Beach. Returning to Santa Monica the conference was formally opened with the customary annual dinner-meeting.

THE PROGRAM

As guest speaker, the Honorable A. E. Stockburger, State Director of Finance, reviewed California's financial status and gave the members a lucid and timely explanation of the State's resources and the method and manner in which public funds are tagged and expended by legislative enactments. He indicated clearly the limited amount of money which is available to State agencies for purposes other than for which specifically collected; said that although the biennial budget of the State of California may run into hundreds of millions of dollars, there are but few of those millions over the expenditure of which State officials have discretionary powers. On this score any request for State funds for sewage research or other justified purposes would necessarily feel the influence of the very narrow margin of excess funds which the State may have available for discretionary appropriations.

The technical session, the morning of September 11, held in conjunction with the city engineers section of the League was well attended. The first paper presented by C. G. Smith of Los Angeles constituted a brief description of new structures and outlined changes proposed for

Los Angeles' extensive sewer system and disposal works. C. C. Kennedy of San Francisco recounted Stockton's proposed plans for the reconstruction of its sewage treatment plants. Motion pictures were then shown by the Chairman, to give a running story of preliminary investigations and construction work upon the County Sanitation District's outfall tunnel and pipe line.

In the afternoon H. N. Jenks of San Francisco presented a comprehensive picture of his applied innovations to the trickling filter and San Diego's assistant city engineer, B. D. Phelps, outlined proposed improvements in sewerage facilities in his city. The meeting concluded with committee reports on operator's schools, voluntary registration of operators, safety regulations for sewer maintenance employees, and proposed and current legislation affecting sanitary works and workers; closing with election of officers for the year 1937.

The following officers were unanimously chosen: President, E. A. Reinke, State Department of Health, Berkeley. 1st Vice-Pres., R. F. Goudey, San. Engr., Water Dept., Los Angeles. 2nd Vice-Pres., Alexander Bell, Wallace & Tiernan Co., San Francisco. Sec'y-Treas., R. R. Ribal, Engineer, Bureau of Sewers, Oakland. Director (5 years), A. M. Rawn, Los Angeles County San. Distr., Los Angeles. Director (2 years) J. I. Ballard, Western Construction News, San Francisco. Member Board of Control, C. G. Gillespie, Chief Engr., State Dept. Health, Berkeley.

FRED D. BOWLUS, Secretary-Treasurer.

The following paper will be published

in

SEWAGE WORKS JOURNAL

Improvements to the Stockton Sewage Disposal Plant

By

C. C. KENNEDY

REPORT OF THE COMMITTEE ON CERTIFICATION OF AND SCHOOL FOR SEWAGE TREATMENT PLANT OPERATORS

PART 1

REPORT OF CERTIFICATION OF SEWAGE TREATMENT PLANT OPERATORS

The purpose of this Committee's report is to consolidate the work of previous committees on the subjects of licensing operators and schools for operators in order that a definite plan can be submitted for the approval of the Association. The excellent reports of these two committees in the past have firmly established,

(1) That sewage works operators desire the protection, value, and support which comes from licensing operators; (2) That they approve the voluntary system of licensing but with a simpler classification than previously recommended; (3) That all sewage treatment plant operators be licensed at the present time without examination on submittal of their record to the Committee for decision as to their proper classification; (4) That if any schools are held for operators that they be put on a practical basis; (5) That it is desirable at this time to make a definite recommendation to put licensing and schools under one committee for immediate action; (6) That the use of the term "certification" in place of "licensing", at least while either licensing or certification is on a voluntary basis, is preferable. Hereafter in this report the committee will employ the term "certification" in place of "licensing".

The American Water Works Association, through its Committee on Certification of Water Treatment Plant Operators, has initiated a plan of voluntary certification of operators in which over 82 have already made application for classification. The principal features of their procedure have been,

1. The establishing of three classes of operators as follows:

First Class:

All chief operators of a wide variety of types of treatment plants where chemical and laboratory control are involved.

Second Class:

All operators operating plants such as rapid sand filtration, slow sand filtration, water softening, iron removal, coagulation, chlorination other than manually operated chlorinators, ammoniation, algae treatment, or taste and odor control.

Third Class:

All operators included in the Second Class but where the operators hold subordinate positions or are more or less on an apprentice basis. In addition, operators of simple aeration and manually controlled chlorination equipment.

2. The establishing of qualifications balancing education and experience according to a suitable scale for each classification.

3. Classifying all operators following the initial period of certification with a written examination.

4. The establishing of a one dollar application fee for the original application and for every subsequent application for higher classification.

5. Renewal of certificates every five years without additional fee on receipt of information that the operator is still engaged in operating works similar to those for which he was formerly certified.

6. Using the word "certification" instead of "licensing" in order to avoid any idea of compulsion.

The new work of this Committee is the establishing of grades of operators which will meet with the approval of the majority of the members of the California Sewage Works Association. The following is a suggested classification submitted for discussion:

Grade 1.

Chief Operators and assistant chief operators employed full time who are in responsible charge of a treatment plant where plant laboratory control is essential to satisfactory operation.

Grade 2.

All full time chief operators, or foremen, where plant laboratory control is not practiced, all full time operators with over five years experience, at plants with or without laboratory control, and all operators who otherwise would be in Grade 1 but who are lacking the proper educational or experience requirements

Grade 3.

All regular operators with less than five years experience, all part time operators including those in responsible supervising capacity, all apprentices, and all operators who otherwise would be in Grade II but who are lacking the education or experience qualifications.

In classifying operators the Committee shall grade them either as "Grade I Operator," "Grade II Operator," or "Grade III Operator." Then, further, it shall add on the certificate the general type of plant at which the operator is working at the time he is certified. A modifying phrase in each case shall be determined by the Committee and shall as tersely as possible convey the general process of treatment where the operator is employed.

The educational qualifications for the different grades of certification shall be as follows:

Grade I Operator.

Grade I operators shall be at least 25 years of age, shall have had not less than five years responsible or semi-responsible charge of operation of a sewage treatment plant, shall have had at least one year full time responsible charge of a sewage treatment plant and each year up to four years spent in a university as a student in sanitary engineering, subjects shall be counted as a year of semi-responsible charge.

Further, any application for promotion by Grade II operators for ratings as Grade I operators and who lack a minimum of two years university training in sanitary engineering subjects may submit as

its equivalent a record of at least 200 hours attendance at Short Schools, Special Training Classes, or in Extension Courses on subjects acceptable to the Committee on Certification.

Grade II Operator.

Grade II operators shall be at least 25 years of age, shall have had not less than five years experience at full time continuous employment in the operation of any part of a sewage treatment plant and shall be high school graduates or equivalent. Credit for attendance at Short Schools, Special Training Classes, or in Extension Courses on subjects acceptable to the Committee on Certification shall be accepted as experience at full time continuous employment in the operation of any part of a sewage treatment plant on the basis of 100 hours of instruction to one year experience.

Grade III Operator.

Grade III operator shall be at least 21 years of age and need not have any educational or experience qualifications if operating under a Grade I or a Grade II operator. If the Grade III operator is operating a plant on a part time basis and is otherwise performing the duties of a Grade II operator he shall be required to have the educational and experience qualifications of a Grade II operator when operating on a part time basis in order to secure a certificate.

After September, 1937, all applicants for any of the grades of operators shall be required, regardless of educational and experience qualifications to take both oral and written examinations to be held annually by the Committee on Certification at the Fall meeting of the California Sewage Works Association.

It is recommended that a committee be authorized to send out application blanks and letters of transmittal explaining the purpose of the voluntary certification which shall also state the classifications, educational qualifications, and shall issue certificates according to the following rules:

1. That all operators applying for certification prior to the September meeting of the California Sewage Works Association in September, 1937, shall be classified by the Committee and be granted certification without an oral or written examination;

2. That an application fee of one dollar be required for the original application and for every subsequent application for higher classification;

3. That certificates shall be renewed every five years by a validating tag issued when evidence has been submitted to the Committee that the operator is still employed in a capacity equivalent to that for which he was originally certified.

A recommended application blank is attached hereto.

It is also recommended that certification shall be in charge of a subcommittee of the General Committee on Voluntary Certification of, and Schools for Sewage Treatment Plant Operators in the future be restricted to three members, one from the north, one from the south, and one alternating from north to south and each serving a three year period with one new appointee made each year to provide for proper

holding over of terms. These three members shall consist of the Chairman and any two of the general committee selected by the Chairman.

It is further recommended that the Secretary-Treasurer of the California Sewage Works Association act ex-officio as treasurer of the sub-committee on Certification and that all funds received from operators or from any other source shall be kept in a special account by him subject to withdrawal only upon order of the Chairman of the sub-committee on Certification.

The Committee Recommends:

1. That a Short School for Operators be established during the ensuing year;
2. That said school be conducted jointly, at least during the first year, with water treatment plant operators organized by the California Section A. W. W. A.;
3. That a tentative offer by the School of Government of U. S. C. to include such a school in their Institute of Government week be accepted for the initial session of the School;
4. That the course of study and instructors for such a school be selected at a later date by the joint committee of the C. S. W. A. and the A. W. W. A. and that the following general topics are recommended to be included:

Sewage Treatment in Relation to Disease
Study of Sewage Treatment Processes
Review of Design Data
Laboratory Control
Interpretation of Results
Care of Electrical and Mechanical Equipment
Maintenance of Plant Grounds

5. That a revolving fund of $100 be set aside from the C. S. W. A. funds to be used to put on the 1937 Short School which shall be reimbursed in full from fees collected from those attending the Short Course and that the Secretary-Treasurer of the C. S. W. A. act ex-officio as treasurer of the sub-committee on Short Schools and that all funds received from operators for instruction material shall be kept in the revolving fund account.

In addition to the establishment of the 1937 Short School the Committee recommends a study of the question of the desirability of securing Federal aid for a more thorough Short School. The George-Deen bill provides partial funds for "in service training of public employees" in Short Schools. Only selected operators can attend and their traveling expenses plus a small salary is paid by the government while the operator is away from his plant on a leave of absence. This plan has worked out well for health officers, sanitary inspectors, and sanitary engineering schools. Already several educational centers throughout the country have availed themselves of this service. The University of California is now holding one school for health officers and has already completed one school for sanitary inspectors. These schools, about 15 weeks in length, which were held at Berkeley, draw students from all the western states, including Idaho, Utah, Montana, and Colorado.

APPLICATION FOR CERTIFICATE

To Operate Sewage Disposal Plants and Equipment

BOARD OF EXAMINERS

Committee on Certification of Sewage Works Employees

CALIFORNIA SEWAGE WORKS ASSOCIATION

Date....., 193.....

Full Name
(Print Plainly)

Address
(City)

Date of Birth..... Age.....

Location of Plant at which applicant operates or has operated.....

Name of Plant Owner.....

Population Served.....

Capacity of Plant: Average Output.....M.G.D.; Maximum.....M.G.D.
Give a brief description of the above plant, including type of plant, kind of chemicals used, type of equipment, etc.....

.....

Are you physically capable of performing all plant operation duties?.....

Have you any physical defect?.....

In what capacity are you now employed?.....

Location of employment.....

Name and address of employer.....
The information contained in this application is true to the best of my knowledge.....
(Signature of Applicant)

Notice: The application fee of $1.00 is due and payable at the time of filing application.

APPLICANTS WILL NOT WRITE BELOW THIS LINE

Written Examination..... By.....
(Date) (Examiner)

Oral Examination..... By.....
(Date) (Examiner)

Rating Class.....

Certificate Issued..... Approved.....
(Date) (Chairman of the Board)

EDUCATION

List below City and State in which you attended school.	Circle the last grade completed	Did you graduate?	Give date of leaving or graduation
(a) Last common school	1 2 3 4 5 6 7 8		
(b) Last Junior High (if any)	7 8 9		
(c) Last High School (if any)	1 2 3 4		
(d) College or University	1 2 3 4 B.S. M.S.		
(e) Operator's Schools Attended			

(f) Give any other education or training you have had: Business College, Correspondence, etc.

EXPERIENCE

List below, starting with last engagement at the top, where you have worked and what you have done during the last 10 years.

Dates of Service							
Date from	Date to	Total Years	Employed by Name	Address	Wages	Occupation	Reason for Leaving

Summarize any additional education or experience you have had which qualifies you for the position of Sewage Treatment Plant Operator.....

Give three references to your operating ability (Supervisors, Foremen, etc.)

1.

2.

3.

Obviously it is desirable to investigate the possibility of securing Federal aid for instruction of Sewage Treatment Plant Operators.

The questions now to be investigated are:

1. Can Federal funds be secured for a Sewage Operators School?
2. How can funds be raised to match Federal support?
3. Can moneys of the State Vocational Fund be legally expended in matching Federal funds when used for Sewage Treatment Plant Schools?
4. Through what agency and how would prospective students be selected?
5. Should such schools be held in the north or south or both?
6. Who should formulate its program?
7. Who would be the instructors?
8. Should not such a school be at least two months long?
9. Since the California Sewage Works Association is only State wide and if financed in part by the government will be available to all the western states, how can all possible conflicts be avoided?

The Committee recommends favorable action on its report.

Respectfully submitted,

R. F. GOUDEY, Chairman
W. A. ALLEN
J. I. BALLARD
A. P. BANTA
H. F. GRAY
W. R. UPDEGRAFF

DISCUSSION:

Mr. Gray:

I think we ought to acknowledge the very fine work done by Professors Reynolds and Hyde.

Mr. Batty:

What effect would it have if an operator took a civil-service examination? What would be his status under those conditions?

Mr. Goudey:

This is purely a voluntary matter and no city or organization is bound by the action of this organization. It is simply to advance the art of operation. There is no thought, even in the immediate future, of making it compulsory or required.

Mr. Rawn:

These rules and recommendations form a ground work just like a constitution. It is up to the committee to interpret them and they can apply them as they see fit or deem desirable. This is simply a groundwork and nothing in it implies or says: "**must** be done".

Mr. Alva Smith:

I believe this committee has developed something very practical. I have struggled with this before. It looks like you have at last worked out something that will get us somewhere—and I am really glad the committee has been able to accomplish so much.

Mr. Rawn:

The report recommends that a committee be appointed to function as a licensing commission or a certification commission. Is there a motion to that effect?

Motion made by Hoskinson, seconded by Pomeroy, carried and so ordered.

Mr. Rawn:

This report contains definite recommendations. Now open for discussion.

Mr. Batty:

Have you any idea what the cost of this university course would be to the operator?

Mr. Goudey:

$10.00 plus $1.00 for the notes, if the salary is over $200.00 a month; $5.00 plus the $1.00 for notes, if less than $200.

Mr. Gray:

How is the Sewage Works Association to get this $100 revolving fund back?

Mr. Goudey:

I think I should explain: The opinion was that there should be three sessions in the morning and three in the afternoon. Mimeographed synopses or notes of the subjects for these sessions would be prepared in order to promote discussion and thus not permit the men to be just lectured to. There would be a charge of about $1.00 for these notes. The revolving fund would be up to $100 rather than actually $100.

Mr. Rawn:

How about the appointment of members for this committee?

Mr. Goudey:

The schools committee will necessarily be larger. At the University for instance, Dean Henry calls a meeting and we establish an advisory committee, then a schools committee comprised of probably thirty or forty. But the advisory committee, consisting of three or five men would be all members of this Association—having as their duty the formation of the actual program. Whatever we do would have to fit in with the general plans of the schools committee.

Mr. Rawn:

Comments about Federal money—has anyone any knowledge of that situation?

Mr. Gray:

I happen to be teaching a school for health officers at the University of California. Many of those who are not strictly health officers but are studying . . . (may be placed in positions later) . . . are paid a good salary during the time they are there in training, together with traveling expenses, etc. The State's contribution consists of part of the salaries of the various instructors in the University. We have just completed plans for a six-weeks course of instruction for sanitary inspectors to be given at Berkeley and Palo Alto, a total of twelve weeks in all. For health officers there will be two types of instruction: one 15-week course for employed men and another of 31 weeks for those as yet not

employed. It is entirely possible that under the operations of this bill and following the same general line, we might be able to obtain six weeks of intramural instruction at some university followed by practical experience at plants so that they will get a well-diversified education. I think it would be highly desirable to investigate that phase of the question very carefully. With such training I believe you will turn out operators far better trained than those who are given only one week of short school. However, I am not minimizing our own short school plan. That is surely a step in the right direction and it may serve as an entering wedge for the more complete and more advantageous training.

Mr. Rawn:

Any further discussion or questions? If not the report will be acted upon as indicated from the floor.

REPORT OF AUDITING COMMITTEE

Sept. 11, 1937
Santa Monica, Calif.

Calif. Sewage Works Assn.
Mr. A. M. Rawn, President.
Gentlemen:

We, the undersigned, in accordance with your appointment have audited the accounts of the California Sewage Works Association for the year 1936, and, in our opinion, the following statement expresses the financial transactions for the year, and the present condition of the Treasury.

BALANCE SEPT. 20, 1935		$ 583.80
CASH RECEIPTS 1936—		
Journal Advertisements	$642.50	
Journal Sales—Reprints	11.00	
Back Dues	20.00	
Current Dues	416.00	
Advance Dues	2.00	
Refunds	4.00	
		1,095.00
TOTAL CASH		$1,679.00
CASH DISBURSEMENTS 1936—		
Printing of Journal 1936	$484.68	
Federation Membership Dues	218.00	
Stenographic and Misc. Services	44.70	
Printing Stationery and Postage	82.15	
Shore and Beach Protective Association	50.00	
		879.53
TOTAL CASH ON HAND SEPT. 8, 1936		$ 799.77

Respectfully submitted,
WILLIAM T. INGRAM, Chairman
D. D. KENNEDY
A. T. WINTERSGILL
Auditing Committee.

ROPOSED REGULATIONS TO INSURE SAFETY IN THE MAINTENANCE, OPERATION AND RECONSTRUCTION OF SEWERS

The object of formulating these rules for safety regulations is to stablish a simple and practical method of procedure and practice that ill protect the lives and health of men at work in and about sewers. he gases in our sewers are constantly increasing in number of kinds nd potency due to new manufacturing wastes emptied therein, causing n increasingly dangerous condition against which the workman must e protected.

recautions Against Traffic

Available trucks, autos or wagons shall be parked in line with the affic, close to the manhole at which the work is to be done to form barrier against traffic. "Men at Work" signs shall be placed in front nd in back of the manhole, or in front and back of the trucks, etc., orming the barriers.

In case trucks, etc., are not available or it is not possible to use same, Men at Work" signs and barricades shall be set up instead of said rucks, and a man with a red flag shall guard the manhole while it is pen. One or more red flags shall be placed on each side of the manhole about five feet out therefrom).

In case of emergency when trucks, autos, street signs, or flags are not vailable a man with a red flag must guard the manhole, continuously hile it is open.

Every open manhole must be protected with barriers, flags, etc., at ll times. On roads or streets where the traffic is fast moving, "Warn-ng" signs and flags shall be placed 100 ft. or more ahead of the location f the work.

At night red lights shall be used instead of red flags.

After installing protection against traffic as above described, the ork may proceed.

Dangerous Gas

Before men enter the manhole the foreman or man in charge of the ork shall ascertain if there is dangerous gas or gas in dangerous uantities in the sewer.

eration of Sewer

If gas is present, the sewer is aerated by opening one or more man-oles above and below the manhole which is to be entered.

This process of aeration may be hastened and considerably helped, n smaller sewers, by flushing out with water. If after the above ethods have failed to aerate the sewer or large quantities of gas are resent in the sewer in which work is to be done, the sewer shall be erated by a supply of fresh air. This can best be done by the use of a asoline or electrically operated blower connected to a canvas hose or ght metal air line to convey the fresh air to the sewer.

ntering the sewer

When no gas is found, or gas has been eliminated, men may now nter the sewer and perform their work.

One or more men should enter the sewer and two men work at the top of the manhole to aid and assist the men in the sewer.

Ropes may be attached to the men in the sewer leading up to the men at top. (The use of ropes is not insisted upon as it is considered by many to impede the work.)

In all cases where ropes are used the men shall be equipped with safety belts.

Dangerous Gas in Sewers

Where work has to be done when gas is present in the sewer in dangerous quantities special precautions shall be taken.

Men working under these conditions shall be equipped with gas masks and the foreman or those in charge shall see that men do not enter the sewer unless wearing masks. Ropes shall be attached to the men working in the sewer and the men be equipped with safety belts.

A sufficient number of men shall be at the top to render the necessary aid and assistance to the men working in the sewer (depending on the size of the sewer and type of work). When men are working in the sewer one or more men shall be stationed at the bottom of the manhole.

APPARATUS

Testing for Insufficient Oxygen or Presence of Gases

The Flame Safety Lamp

The Flame Safety Lamp is a lamp in which the flame is protected by a double, fine steel wire gauze covering.

Hydrogen Sulphide Detector

Other more accurate instruments for detecting the presence of explosive gases are:

Burrell Methane Indicator.
Martienssen Methane Detector.
U. C. C. (Union Carbide Co.) Methane Detector.

Carbon monoxide may be detected by the Iodine Pentoxide Indicator, a very accurate color test.

Carbon monoxide can also be detected by small animals. Canaries are the best. Others are the mouse, chicken, small dog, pigeon, etc.

Hydrogen sulphide intensity can be detected by lead acetate or other indicating papers.

GAS MASKS

The only satisfactory and "fool proof" gas mask that should be used by the ordinary sewer worker is the hose-type mask, equipped with a hand pump attachment, thereby supplying the worker with fresh air from the outside.

All other types of gas masks should be used only by men who are specially trained and instructed in their use.

Type "D" Self-Rescue Respirator

This is a very portable outfit, to be hung from the belt, or carried in the pocket.

It consists of a small can and a mouthpiece and nose clip. Chemicals the can remove gases. It is designed more particularly as protection gainst carbon monoxide. This respirator will protect a man for half n hour.

ype "N" Gas Mask

Has a face piece to protect the eyes, with a tube to a cannister conining chemicals, all supported by a harness. This gas mask protects e wearer from all gases, smoke and vapors but it requires that there oxygen in the air (none of the chemicals furnish oxygen). One-can arge of chemicals will protect a man for two hours.

These gas masks must be used with a Flame Safety Lamp to warn hen the oxygen is below life supporting quantity.

lf-contained Oxygen Breathing Apparatus

This type must be used where there is little or no oxygen. The makes ost commonly in use are:

The Gibbs Apparatus;
The Paul Apparatus;
The McCaa Apparatus;
The Fleuss-Davis Apparatus.

All of these makes have compressed oxygen tanks, with hose to mouth d nose.

RESUSCITATION

When men are overcome with poison gases or lack of oxygen, they ıst be restored by means of manual methods of artificial respiration, llowed by oxygen applied with an Oxygen Inhaler. The latter instruent requires a trained man to operate it.

Istruction of the men

The men should be instructed orally in the above procedure and gulations and also practically instructed, and the methods and use o the apparatus demonstrated to them within the sewer itself, until t y become thoroughly proficient with the methods of procedure and u of the apparatus.

All foremen should take courses in first-aid and methods of resusciion. All the men should also be encouraged to take these courses.

Sıall City Equipment

n regard to equipping a city or small town with safety apparatus, tl process may be somewhat after the following procedure:

A more or less complete set of gas masks, oxygen breathing appaıus, and resuscitation apparatus should be built up for the Fire Epartment, for it is absolutely necessary in that department in order tosave lives in time of conflagration.

Then this apparatus is available if needed for dangerous sewer condons, whenever such conditions may occur. The sewer department wl then be protected during the time it is accumulating its own apparatus.

ACKNOWLEDGMENTS

We wish to acknowledge our indebtedness for facts and data concening the apparatus as described herein to the following:

Circulars Nos. 33, 34, and 35 of U. S. Department of Commerce o "Advanced Mine Rescue Training," and also Circular No. 30, "Use the Miner's Self-Rescuer," of the same department, and to Mr. F. Ash, in charge of the Safety Division, United States Bureau of Mine located at the University of California.

Also, Mr. J. B. Jones of the Mine Safety Appliance Co. has contri uted valuable information and literature.

GENERAL INSTRUCTIONS AND SUGGESTIONS

Superintendents and assistants and those in charge of the maint nance of sewer systems, etc., should be thoroughly familiar with the sewer system, and all workers should be instructed regarding locatio where gas may be encountered and care that should be used in enterin sewers where cleaning has been neglected, old sewers and sewe where the flow is particularly sluggish.

In maintaining sewers in a safe and economical manner it cann be stressed too strongly that the workers be experienced. Experience men know when and how to look for danger; are not unduly frigh ened by some conditions that are encountered normally.

A majority of a maintenance crew should be experienced men.

Never send out a crew composed entirely of "green" men.

Iron ladders should be used to go down manholes where the ste are weak or inadequate.

Care should be taken in ventilating sewers by blowing out gas n to cause discomfort or injury to the traveling public.

In testing sewers for gas never use an open flame light; this ma cause an explosion.

A flame safety lamp does not give proper information when lowere into a sewer; it must be in such a position that the operator can loo directly into the flame.

It is recommended that sewer systems be tested periodically f explosive gas, and when found, every effort be made to locate sour and eliminate gas.

No worker must be allowed to smoke in any sewer or manhole- shots of gasoline come down the sewers from time to time which ca cause an explosion.

When the oxygen content of the atmosphere in the sewer is insuf cient to warrant entering the sewer with perfect safety, the sewer too dangerous to be worked in. If entrance under these dangerous co ditions is absolutely necessary, then the sewer should be entered b men with oxygen tank equipment and these men should be experts i the handling of such equipment.

It is advisable on first entering a manhole of more than ordina depth (8 or 10 feet) for the worker to wear a safety belt with ro attached.

Respectfully submitted,

F. A. BATTY, Chairman;
W. S. RANTSMA,
T. F. EASTMAN,
BEN BENAS,
F. D. BOWLUS.

DISCUSSION

Mr. Rawn: Thank you, Mr. Batty. Prior to comment I will take the liberty of filing the Membership, Financing Journal and Publicity Committee reports. The discussion of the report of the Committee on Safety Regulations is now open. If this organization desires to approve and adopt the type of sewage regulations recommended by your committee, it occurs to me that this Association can do no better than to put them into a manual and announce in **Western Construction News, Western City, Engineering News-Record** and our own **C. S. W. A. Journal** that this has been done—and that the manual will be available for others. The printing of the first copies are a bit costly, but the additional hundreds are comparatively inexpensive. This is a brief, concise statement of how to protect men in sewers and we ought to get it broadcast, prepare it as the American Society of Civil Engineers does, put it into a manual and see that it is distributed.

Mr. Ribal: Mr. Chairman, if these sewer regulations are to be published I would suggest that, since men working in sewers are not always well superintended and usually not very adept at following written instructions, pictures and cuts should be included making the explanations more readily understandable.

Mr. Ingram: It seems to me that if we have them put into a bulletin we should be very sure that the recommendations made are just exactly what we want to make. I would suggest accepting the report tentatively and have another committee invite written comments upon the revised form—and mimeograph it for distribution among the members before publication.

Mr. Pomeroy: It might be wise to pick out some fifteen or twenty men and ask them specifically to work on it.

Mr. Rawn: This is about the fourth or fifth time the report has been submitted.

Mr. Kennedy: I would like to make a suggestion: since this subject has been under consideration by men who have had to do with the maintenance of sewers and are as familiar with it as anybody in the state—and the best brains of this organization have given it careful attention. I would like to amend the motion previously made, by a new motion to the effect that we here and now adopt this set of safety regulations as the work of the present committee and amend it later if necessary. Out of courtesy to these men and in recognition of their careful preparation of these regulations, I move that we adopt this report as presented, have it printed and circularized, and submit it to the League.

Mr. Rawn: Is there a second to the motion? Motion seconded and carried and the first motion therefore lost.

Mr. Hoskinson: How about having it incorporated with the State Safety Regulations and let them do the printing?

Mr. Rawn: I think that should be considered. Do you wish that to be made as a motion?

Mr. Batty: That matter was taken up with the state some time ago

and they seemed to have so many different ideas that it was given up, impossible to collaborate.

Mr. Rawn: Is it the sense of this meeting that we adopt Mr. Batty's report as read and have it printed and circularized in accordance with the amended motion?

Mr. Gray: I move that we refer it to the Board of Directors to dispose of as they see best.

Mr. Rawn: Then the amended motion stands—so ordered.

REPORT OF COMMITTEE ON LEGISLATION

After a conference by the writer with Mr. R. E. Mittelstaedt of Sacramento, Chairman, and Mr. C. C. Kennedy of San Francisco, member of the Legislative Committee of the California Sewage Works Association, it was agreed that the subject of pollution of navigable waters with especial reference to National bills relating to the prevention of such pollution should be brought to the attention of this Association at its Ninth Annual Convention.

As the writer, who is a member of this Legislative Committee, had already attended a meeting of a joint committee of members of various groups of business men at the Los Angeles Chamber of Commerce to review these National bills, it was considered by the other members of this Legislative Committee that the writer could properly present this report on this important subject.

The total number of such National bills that were recently presented to the last Congress were eleven, six being through the Senate and five through the House of Representatives. After a study of all of these bills and as most of them are somewhat lengthy, the writer has outlined the features given in Senate Bill 4342. This Bill introduced by Mr. Copeland, last February, was the only bill recommended for passing by the Los Angeles Chamber of Commerce.

Senate Bill 4342 would create a Division of Stream Pollution in the Bureau of Public Health Service, under a director who would be a commissioned engineer officer of the United States Public Health Service, detailed by the Surgeon General. The Secretary of the Treasury on the recommendation of the Surgeon General would be authorized to assign such engineers, attorneys, experts, assistants and consultants from the Public Health Bureau as are available. If not available, the Secretary could appoint the same on recommendation of the Surgeon General.

This Division could make such expenditures as would be necessary for administration of this act, and as would be provided by Congress. The Division would cooperate with agencies in the several States authorized to deal with water pollution, with a view to: (1) Make such studies and surveys to determine the need for and devise methods for conducting preventive and corrective measures relating to water pollution in the several States; (2) Coordinate activities of the States for

prevention of water pollution; (3) Encourage enactment of uniform State laws and compacts between States for such prevention.

The Division would be authorized to collect and disseminate information, to make available to State agencies the results of the surveys and studies conducted by it and other agencies, and to assign experts to assist and advise State agencies without charge.

Brief reports on the other ten bills are as follows: Senate Bill 3958 would provide a National Resource Committee, including seven Cabinet Secretaries and three members at large. The committee would appoint and fix salaries, and appoint attorneys and experts without regard to Civil Service laws.

The Committee would classify the navigable waters of the United States into districts, to be known as Sanitary Water Districts, and fix the standards of purity in each district for both navigable waters and tributaries thereof, and set up minimum requirements for the treatment of polluting material before it is discharged thereinto. In each Sanitary Water District, boards would be appointed by the committee to arrange for loans and institute proceedings for prevention of pollution.

Senate Bill 3959 would amend the Oil Pollution Act so as to include sludge, acids, and sewage in liquid state. This bill would place control with the Federal Government, rather than with the states and communities interested.

Senate Bills 3959 and 3958, after amendments on June 1st last, were reported upon by the Committee on Commerce, with recommendation that they pass.

House Bills 8992 and 11064 were practically the same, one introduced in July, 1935, and the other in February, 1936. House Bill 11064 provides for an Anti-Pollution Board, including the Secretary of War and three members at large, each of whom would receive $6,500 a year for six years. This board would be given the power to institute proceedings to abate water pollution in each Sanitary Water District.

Senate Bill 4350 and House Bill 12102 are practically the same. They would create a Division of Stream Pollution Control under the Surgeon General of Public Health Service. These bills would authorize $250,000 for the year ending June 30th, 1937, and $750,000 a year for ten years, of which $250,000 would be paid to states, each state to appropriate a like sum to that received from the government.

Senate Bill 4349 and House Bill 12103 are practically the same. They authorize the Chief of Engineers, under the Secretary of War, to investigate conditions of navigable waters as affected by sewage, industrial waste, and other deleterious substances. The bills would provide for studies and estimates of cost for surveys over the United States. When the state or community benefited would pay its share of the cost, the chief engineer would make the survey and report.

Senate Bill 4627 and House Bill 12764 presented in May, 1936, would be known as the Stream Pollution Act. As in Senate Bill 4342, the division of government created for control of this act would cooperate with state agencies for elimination or reduction of water pollution, and receive yearly $300,000 for its establishment and maintenance, and

$700,000 annually for ten years to be paid to the several states for investigation and studies to prevent stream pollution, this amount to be used for salaries for such engineers, attorneys, experts, and others as may be needed.

A study of these various national bills, excepting Senate Bill 4342, which protects the rights of states, shows that each contains undesirable features, ranging from unenforceable requirements regarding the disposal of waste matter to the authorization of large amounts of money in advance of actual knowledge of the scope and extent of the problems. As studies and surveys of present conditions of water pollution are much needed, your Legislative Committee recommends that the California Sewage Works Association authorize its Legislative Committee for the coming year to continue the study and survey which this report has outlined, with the intent that this committee may be able to submit to the Directors of this association on a short notice, recommendations in regard to the approval of bills on this matter, that will be presented to the next congress; and with the further understanding that if a majority of these directors approve of such recommendations, this committee can be authorized to submit their recommendations to those members of congress who would be in a position to further such recommendations.

Respectfully submitted,
W. T. KNOWLTON,
For the Legislative Committee.

DISCUSSION

Mr. Knowlton: Read the report, and remarked: This matter of legislation is really a live issue. It is one which affects the entire United States and this particular coast especially. We should have certain facts before we try to go ahead. Action should be taken early on the presentation of these bills. It is believed by the oil interests that something will be done. Your committee has recommended that your next Legislative Committee be empowered to take action either approving or disapproving the bills that will be presented.

Mr. Gray: Will the Legislative Committee do anything about the next legislature which meets in January? How about state legislation?

Mr. Rawn: Mr. Knowlton, can you answer that suestion?

Mr. Knowlton: We considered that. Next January your representatives will take some action.

Mr. Pomeroy: Some of them should have power to institute proceedings for the control of undesirable pollution. Would the bill recommended by the Chamber of Commerce have that provision?

Mr. Knowlton: No.

Mr. Pomeroy: It seems to be a good thing to institute proceedings to prevent undue pollution. If a bill is passed that does not provide for those compulsory requirements it will be hard to get another one through later on. It would be desirable to have a bill embodying that compulsory feature right at the outset.

Mr. Knowlton: It is the belief of myself and others that we who live in California feel that we know more about the local situation and that state and local knowledge is better here than it is in Washington.

Mr. Pomeroy: What recourse is there if it is entirely in State hands?

Mr. Rawn: (Comments on old laws of England). . . . A law was passed about 1865 which contained practically all the elements described by Mr. Knowlton. In 1935 they were suffering from the same condition. Went back to the local River Boards and got together on a basis of understanding. I am not at all sure but that what Mr. Knowlton has expressed is very similar. As soon as you bring it back to the locality you will begin to achieve results.

Mr. Kennedy: As a member of the committee: In taking on the work in coming years, your Legislative Committee should be aware of what is on foot and know what the Federal government has under way. That knowledge makes it better for us to make recommendations to our members in the Legislature and the Senate. We should keep informed and at least know what has transpired in legislative matters.

Mr. Knowlton: If, before the next spring meeting, it is necessary that some action be taken, we might do as we did recently for the approval of that civil-service bill. I don't know that any action will be so required, but should it come up, your committee can do nothing without the approval of your Directors.

Mr. Rawn: You have heard the report of the Committee on Legislation. Is there a motion that it be accepted as read?

Motion made by Hoskinson, seconded, . . . and report accepted.

RECONSTRUCTION OF THE LOS ANGELES COUNTY SANITATION DISTRICTS JOINT DISPOSAL PLANT AND CONSTRUCTION OF SEWAGE DISPOSAL TUNNEL AND OCEAN OUTFALL

By

A. M. RAWN
Assistant Chief Engineer
Los Angeles County Sanitation Districts

Mr. Rawn showed motion pictures of plant and tunnel construction and explained them.

STATE FINANCES

By

A. E. STOCKBURGER*

Mr. President, Members of the California Sewage Works Association and Friends:

It is a distinct pleasure to be with you this evening. I know many of you personally and recall with a great deal of vividness some of the difficulties we worked out together in the problems of a number of your Southern California cities.

All of you—city, county and state employees—know how important a part finances play in the problems of government. There is more misinformation and less understanding of the affairs of state than other types of government because it is a little further removed from us. It is impossible to get a picture of the state government—that is, a comparative picture that you can retain—from what you read in the newspapers or current periodicals, or hear from time to time over the radio.

Tonight I shall attempt to give you a picture of our state government in its relation to the whole. In order to do this, it will be necessary to use some figures. I will use as few as possible. However, I shall use them for comparative purposes only and try to leave with you a distinct picture of some of the problems which the state has to face, problems that are yours rather than those of state officials.

First, the budget. You have a budget, whether you work for city, county or district. There is certain money set up in that budget which constitutes your expenditure program. The state budget is not a budget of that type. The state does not expend the money set up in the state budget. For instance, we have $430,000,000 in the budget, which appears to be a large sum to be expended every two years. When we look to see where this amount goes, we find $48,000,000 is expended for unemployment relief, resulting from the depression. If we deduct this amount from the $430,000,000, we have $382,000,000 left, of which $217,000,000 is money raised by the state and sent back to be used locally. Of course, that $217,000,000 carries the schools, salaries of Superior Court judges, homes for the aged, orphans, blind, and certain tuberculosis sanatoria, as well as other needs of counties and cities. Deducting $217,000,000 from $382,000,000, we have $165,000,000.

Eighty-eight million dollars of that $165,000,000 represents moneys expended by self-supporting agencies — boards and commissions for doctors, dentists, beauty parlor operators, barbers, etc. They are all ear-marked moneys and not a part of the state government. They are expended pursuant to law enacted by certain groups for the purpose of protecting themselves and the work in which they are engaged.

Subtracting $88,000,000 from $165,000,000 leaves $77,000,000, which sum constitutes expenditures for the general governmenmt of the state.

*Director of Finance, State of California.

This $77,000,000 carries some interesting items: $17,500,000 goes for institutions; that is, state hospitals, home for the feeble-minded and homes for the blind. In other words, custodial care. This problem provides an interesting, but dreary picture.

We have nearly twenty thousand insane in our state hospitals in California. Their number is increasing at the rate of eighteen hundred every two years. We need a new hospital every four years to care for this increase. At the present time there is an overload of five thousand in our state hospitals. The hospital at Patton, Riverside County, has an overload of 44%.

Not long ago I walked through the Napa State Hospital where patients were sleeping on mattresses on the floors, placed just far enough apart to permit a little space to walk between. They were crowded not only in the sleeping quarters but into the basements, parlors, attic and on the porches. There was not a square foot in the whole place unoccupied. It is a crime to have a four-story building, the brick outer shell built back in 1870, crowded in that way. All outbuildings are also crowded to overflowing. I said to the Superintendent, who is the only woman superintendent of a mental hospital in America, and a fine and capable executive, "How do you keep these folks in this way?" She answered, "If they were sane, we could not do it, but many just sit here, staring into space, unconscious of their condition. Under other circumstances, they would have to be cared for differently." The other hospitals are just about as crowded. Think of it! When a person is sick in your home, he gets the finest attention under the most sanitary conditions, but in this big family of Californians—for we are just that, a big family—we have not done what we would for our own. Instead, we have given the worst of everything to those poor unfortunates. Many of them are in fine physical condition and will live a long time. Some are veterans of the Indian wars and have been in the institution over forty years! We need hospital accommodations for approximately ten thousand patients at the present time. In order to provide such accommodations, we proposed a bond issue of $13,000,000 but it failed. The people would not vote it. We are now expending $4,000,000 biennially, which relieves the situation to some extent, but there is a constant gain in new patients. We will soon have gained enough new patients to offset what we have accomplished. The situation is one of which the people of the state have no conception. The papers do not print it. One or two give it a little space now and then, but people pass it over and forget. There is no one interested in those unfortunates.

The situation in the prisons is a little better than it was, but is far from being satisfactory. San Quentin, with approximately six thousand inmates, is the biggest prison of its kind in the world. I was a visitor there just prior to the time they took the Board on a joy-ride and I got a picture of the situation that is rather disconcerting. In company with the warden and other prison officials, I toured the prison. Going through the jute mill, which is the worst place, I was conscious that the guard was always stepping on my heels and wondered why. The warden was walking ahead and I realized that the guard was seeing to it that no one stepped between us. There was an air of tenseness

everywhere. It was known that there were guns concealed by the prisoners somewhere about but no one knew where they were. Finally, we got out into the yard and were looking over a new cell block which had just been completed. I noticed a guard on the wall had raised his gun—a prisoner (a trusty) had stepped up to the warden and given him a letter. I glanced around and realized anew that the whole prison was tense, that any little incident might touch it off. Something did happen, and it might just as easily have happened then, but they wanted the Parole Board.

That situation should not exist in a prison and it would not if we did not have such over-crowded conditions — two and three men crowded together in one cell; the kitchens crowded; the jute mill jammed. The men cannot work and they just sit or mill around. No wonder there is trouble. It is impossible to administer a prison under those conditions and do it efficiently.

San Quentin is not the only prison that is over-crowded. It is not our only problem. Generally speaking, the whole custodial system in California is over-crowded. That simply means that our budget reflects a lot of costs instead of just one or two items.

The item in the budget for custodial care of inmates of the different institutions runs about $17,000,000, plus $5,000,000 for state prisons. When we looked at this amount to see where some economies could be effected in administration we decided that with such over-crowded conditions we could not hope to cut it. When the cost per capita was examined we found that it cost about $17.00 per month per patient for care in an institution. This compared very favorably with the cost in eastern states. Not many would board a well person for $17.00 a month, let alone furnish clothing, medical, dental and general custodial care. It was obvious, therefore, that costs were not excessive and that the item in the budget for custodial care could not be cut.

The Federal Prison Industries Board has been studying our prisons with the idea of making some improvements. They propose to furnish some of the money to do the work and we are inclined favorably to their recommendations. They have made a study in the state of New York, determining what ultimate load might be expected in the institutions of the state by trying to analyze the present population and determine the trends. The result has been rather startling. Their findings show that approximately 18% of the population will receive institutional care at some time or other in their lives. In the early days of our race, nature took care of our unfit, but that has ceased and there is no longer any natural elimination of the unfit. We are holding that lower end of society, keeping, preserving and feeding it, with the result that we are lowering the average of the whole. In New York they go into the schools and try to determine during the early years of an individual what tendency is in evidence. They pick out those who seem to be on the borderline and begin to give them home treatment—special care, special food, many times feeding glands—with the hope that they will be kept from developing into public charges later on.

That is what is going to have to be done in every state, particularly in California, since the need is more acute than in most other states.

The reason for this is that at the first sign of any breakdown of an individual in the East, the doctor says: "I think he needs a change. California has a good climate. Send him out to California." And here they come. In many cases, if the development of the ailment is delayed a little so that they do not become public charges immediately, they become residents. Then we have to keep them. If it is speeded up and they become a public charge before they have lived here long enough to become residents, we send them back to their states of legal residence. We have sent back literally trainloads of them, to all the states and even to the Philippines and India. We have reciprocal arrangements with other states so that they may return all California folk who become public charges and we may do likewise. This matter of custodial care is a real problem and we are going to have to approach its cause from a scientific standpoint by trying to give the unfortunate ones proper treatment at an early age.

Getting back to the budget, there is an item of $13,700,000 for the University of California and $4,400,000 for state colleges, special schools, etc. It costs the state about the same amount for higher education as it does to take care of the unfortunates. It is difficult to control the University appropriation. Last time we tried to hold them down to where they had been, without any increase, but the budget came out of the Legislature with about $2,000,000 more added on.

With a $40,000,000 deficit in the state treasury, we felt that every department should maintain its present budget until we are out of the red; that is, no increases should be allowed. This year, in sending out notices, we specified that minor construction would be permitted whenever it was absolutely necessary—for instance, in an institution where they need a new bakery or a new laundry, or where buildings and property are deteriorating and must be rebuilt—but we will not permit an expanded program to be presented by any department. The various departments should hold their activities within the present scope, and we hope these items will not be any larger than they are now.

We have set aside some $22,000,000 of this $77,000,000 for custodial care and institutions, $18,000,000 for the universities, colleges and special schools, and some $2,500,000 for flood control and odds and ends, making a total of approximately $44,000,000. This, together with the $17,400,000 of bond interest and redemption, makes a total of $62,000,000 —$62,000,000 out of $77,000,000 that we might say is either for education or custodial care. I have indicated that we do not have a great deal of control over the University; patients and prisoners are committed by the courts and we must take care of them; there is the department of social welfare and department of education, the homes for veterans —all come within that total of $62,000,000.

The $17,400,000 for bond interest and redemption is the bright spot of the whole state picture. If we spend $430,000,000 every two years and only $17,000,000 of that is to go toward paying on the debt, things are not so bad as they might look. Half of that debt service, $8,000,000, is for the old highway bonds you have heard so much about. This cost

is met out of the general fund, not out of the gas tax moneys. If education, custodial care, bond interest and redemption is deducted from the $77,000,000 which is controlled, we have only $14,000,000 left that might be termed the actual governmental fund, used primarily for the government of the State of California. It includes expenditures for the legislature, state judiciary, Governor and Lieutenant Governor, Board of Equalization, Railroad Commission, Department of Finance, State Employees Retirement System, Department of Industrial Relations, Public Health, Agriculture, Natural Resources, Public Works, Penology (that is, the pardon board and administration of the penal system), the Adjutant General, National Guard, administrative officers, and miscellaneous—making a total of $14,000,000. The government could function with these departments alone, without anything else. This $14,000,000 is for purely governmental expenses, for those functions in which the state is exercising its sovereign power. Expenditures for these purposes in previous budgets are as follows:

1933-35	$13,200,000
1931-33	19,600,000
1929-31	17,200,000
1927-29	13,700,000

It is evident that this $14,000,000 is nearly what it was in 1927-1929. In other words, this general government of the state is costing in this biennium $5,000,000 less than it did at the peak of the expenditure period.

In closing, I wish to say that the present financial picture is as follows: Assuming that the present revenue laws remain in effect, it will not be necessary to ask for any additional revenues to support the budget for the next biennium. The Governor has stated definitely that his policy is to hold expenditures within the present bounds. Assuming that the revenue structure is undisturbed, no additional revenues will be needed or requested. In other words, the deficit will be wiped out and the budget will be balanced by the end of the next biennium without resorting to any more tax measures or doing any material damage to the services that are now being furnished to the people.

PROPOSED CHANGES AND IMPROVEMENTS IN SEWAGE DISPOSAL AT THE HYPERION PLANT OF LOS ANGELES CITY

By H. G. SMITH*

For the past twelve years over ninety per cent of the sewage of the City of Los Angeles, together with that of Culver City, Beverly Hills, Santa Monica, Burbank, Glendale, Vernon, Manhattan Beach, Hermosa, Redondo and portions of Los Angeles County, after being collected in 3,000 mi. of laterals and interceptors has, upon reaching Hyperion by way of the North Outfall and Central Outfall Sewers, been passed through a screening plant before being discharged into the submarine outfall for final disposal 5,000 ft. off shore in Santa Monica Bay.



Present Hyperion plant consisting of the North Screening Plant at the right with the incinerator in the foreground. In the background is the South Screening Plant which will be remodeled to provide shops, garage and storerooms for the enlarged plant now under construction. The relation of these existing buildings to the present program of enlargement is indicated in the accompanying drawing on Page 37.

This present plant is equipped with coarse bar screens cleaned with automatic rakes, and 10-drum cylinder, Dorr type fine screens, each with a capacity of 40 sec. ft., the plates being punched with 1/16-in. by 2-in. slots. The material refused by the screens, amounting to about

*Division Engineer, Bureau of Engineering, City of Los Angeles.

4.2 tons of dry solids per day or 30 tons including moisture, is collected in elevator pits, raised and discharged into pneumatic ejectors and then conveyed by pipe line to a Morse Boulger type incinerator. The present sewage flow amounts to about 120 m.g.d. during four winter months and 110 m.g.d. during the balance of the year. This process recovers about 3 to 6 per cent of the suspended solids, which run approximately 400 p.p.m., and none of the oil or grease, amounting to about 20 tons per day including the portion saponified.

At the time this plant was erected, fine screening was entirely adequate to meet the needs of the then existing conditions, but with the decided increase in building, bathing and recreation along the adjoining beaches, it has become imperative that a considerable improvement in the treatment of sewage be made prior to the discharging of effluent into the ocean.

In 1935 an appropriation in the neighborhood of $7,000,000, was allocated by the Federal Government, through the Works Progress Administration, for the construction of a new treatment plant to completely replace the now existing one, work on this new project having been commenced on Armistice Day of the same year.

The new plant will be constructed on the 220-ac. tract, known as Hyperion, which has been owned by the City for many years. The tract is covered with sand dunes running back from the ocean to heights of from 150 to 175 ft. in elevation. Work now under way consists in the removal of approximately 4,000,000 cu. yd. of sand in which is included several thousand cubic yards of screenings that were buried prior to the installation of the incinerator.

While these screenings amounted to only approximately 10,000 to 15,000 tons of dry solids, due to the fact that they were discharged from a pneumatic pipe line into trenches and then buried with a drag line it has been found necessary to remove with the screenings, approximately twenty times as much sand. Thus far about 100,000 cu. yd. of this material have been removed by steamshovels and trucks, loaded into barges and towed 12 mi. to sea for final disposal.

In accordance with instructions from the W.P.A. that the sand must be removed as far as possible by hand labor, a 24,000 g.p.m. salt water pumping plant was installed on the beach, water forced up through 30-in. steel pipe feed lines to the higher elevations and there discharged into wooden flumes. The men then shovel the mixed sand and screenings into these flumes along the foot of the slope.

The removal of this material, in the process of leveling off the site, constitutes Unit 1, so that actual plant construction, to be included in following units, cannot commence until certain portions of Unit 1 are completed.

The new plant design contemplates, for a time at least, only primary sedimentation with sludge digestion, vacuum filter dewatering and heat drying, the sludge then going to the incinerators or to fertilizer bins as the market may dictate.

While the general layout and a considerable amount of design detail relative to buildings, structures, pumping plant and piping have been

completed, treatment plant practice and design are so rapidly changing that undoubtedly many modifications may be in order before construction is actually accomplished.

The proposed sequence of flow is as follows: Sewage arriving at the plant will first pass through trash racks, grit chambers and grease skimmers to a distribution chamber, there to be divided more or less equally into six separate conduits, each connected to one sedimentation tank. The effluent from each tank, after passing through a metering device, will be collected in a series of conduits and conveyed to the existing submarine outfall sewer for final disposal in Santa Monica Bay.

The sludge from the sedimentation tanks will be pumped to decanters or directly to primary digestion tanks, from which it will flow by gravity into secondary tanks. The digested sludge after being elutriated, flows to storage tanks from which it is pumped to the basement of the filter building and raised by elevator to the conditioning floor, there to be treated before going to the vacuum filters for dewatering. From the filters the cake is conveyed to the dryers and then either to the incinerators or to temporary storage for sale as fertilizer.

Returning to the head of the plant and considering the several features in somewhat more detail, it may be noted that the plant is completely by-passed by a channel leading from the by-pass chamber directly to the submarine outfall. The by-pass chamber will be provided with a long weir just above the normal water level, which will permit the escape of surplus water in the event of such a flood as nearly washed out the present plant on January 1, 1934 when the bar screens clogged. Since that date flood gates and a very adequate by-pass around the present plant have been constructed.

In addition to the weir, radial gates will be installed, both in the by-pass channel and in the main channels leading to the bar screens so that flow may be entirely shut off from the plant in an emergency.

Flowing from the by-pass chamber the stream will separate into two 8 x 12-ft. channels in which are to be located the trash racks. The racks and rakes will be of the Jeffries type, or equivalent, the bars to be spaced one inch in the clear. The matter collected by the rakes will be washed off into a flume and conveyed to the comminutor pits to be located on either side of the channel, the comminuted matter returning to the main sewage stream. The bar screens and comminutors will be housed by a two-story building, on the second floor of which may be installed a portion of the chlorine equipment to be used principally for odor control. In this connection, it may be desirable to install one or more chlorine plants or chemical feed stations along the sewer above the plant. However, as far as the plant is concerned, the use of chlorine is contemplated only occasionally.

There will be two detritors or grit chambers, each capable of handling the entire flow. Detritus is to be disposed of in the ocean by means of an ejector and pipe line.

Passing into the skimming tanks, which are three in number, each 45 by 90 ft. and 12 ft. in depth, the sewage is to be first aerated by means of high-pressure water jets, and will then enter the skimming

chamber where after a detention of several minutes, it will be discharged through submerged outlets while grease rising to the surface will constantly be skimmed by a series of vanes operating at right angles to the flow of the stream. The grease and other matter removed will pass through a shredder and on to storage and decantation tanks from which it will be pumped to the incinerators. The skimming tanks and distribution chamber will be housed.

Flow through the distributing chamber to the clarifiers will be controlled by motor-operated gates, while a series of dials connected with metering devices will indicate to the attendant the quantity of effluent passing from each tank.

The six sedimentation tanks are to be of the center-feed type, 200 ft. in diameter with 16-ft. center and 6-ft. sidewall depth. Designed for an ultimate peak flow of 70 sec. ft., the present average peak flow of 40 sec. ft., would give a load rating of about 825 gal. The tanks are so spaced that filtration equipment may be added as an annular extension to each unit or as a separate feature.

The elevation and location of the decantation, digestion, elutriation and storage tanks, are arranged in such a manner that sludge, once pumped to the decantation tanks, may pass through the entire series by gravity, while supernatant from any of these will flow to the head of the plant in the same manner.

The decantation tanks, four in number, will be 24 ft. in diameter, of 32-ft. side-water depth with draw-off lines spaced at about 2-ft. intervals in the upper 27 ft., and have sealed covers and conical bottoms.

The stage digestion group will consist of three heated primary tanks, each approximately 110 ft. in diameter and 34-ft. side-water depth, and be equipped for either stirring or some form of recirculation.

The secondary tanks, also three in number and of approximately the same size, will be unheated and provided with a type of floating cover, each forming a holder capable of storing 175,000 cu. ft. of gas.

The Genter process of elutriation is being seriously considered and may be accomplished by the counter-current method, using two 60-ft. center-feed sedimentation type tanks, with a building housing the pumps, aerated washers, control valves and meters.

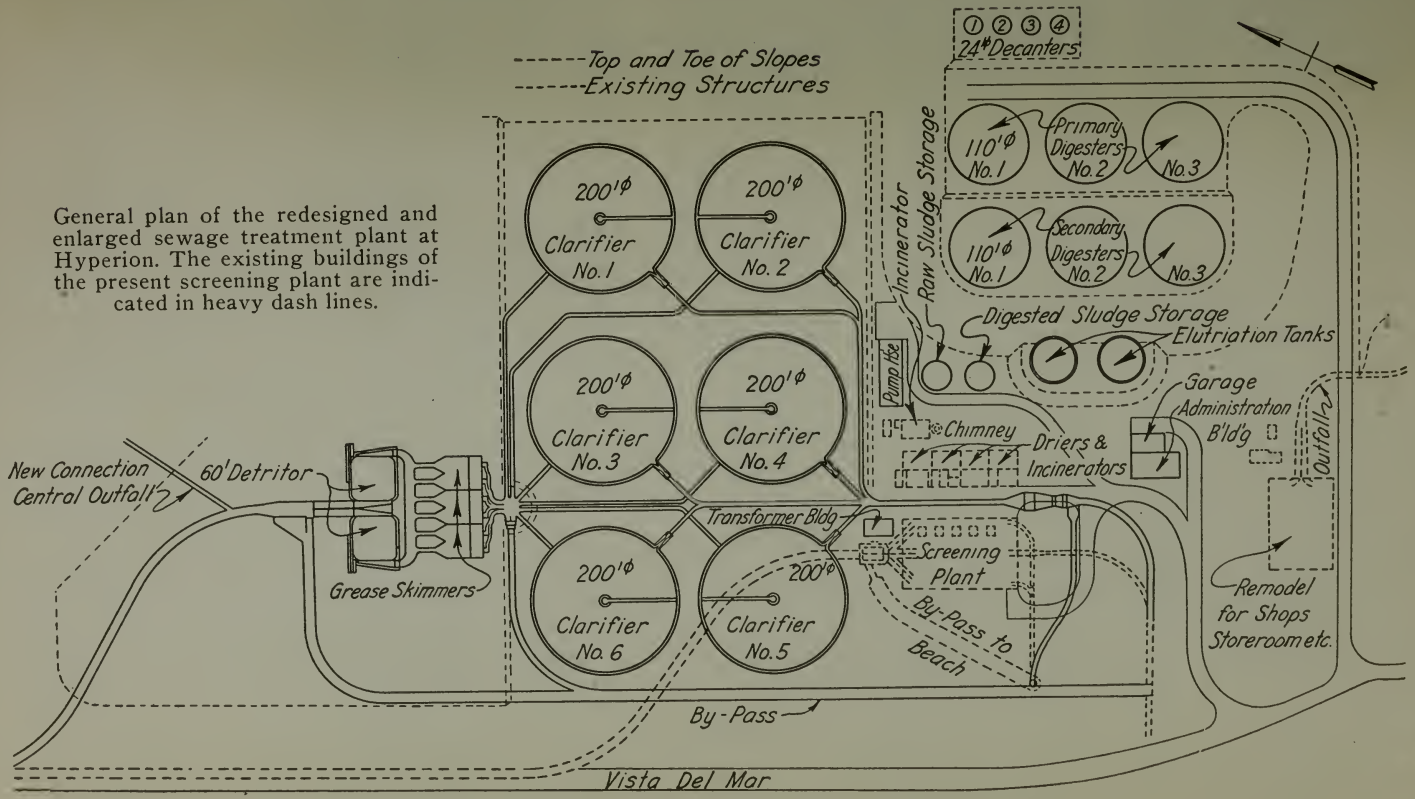
Gas produced will be used in connection with the drying of sludge for fertilizer, the operation of gas engines to furnish a large portion of the power required for the plant, the firing of an auxiliary boiler to furnish hot water, in addition to that coming from the engines to heat the primary digesters, and for forge, laboratory and the heating of buildings.

The north screen plant building, 97 ft. by 161 ft., will be remodeled to contain the vacuum filters, the conditioning plant and the engine room.

Five drum-type vacuum filters, 11½ by 14 ft., will occupy very nearly the same locations as the five Dorr screens on the easterly side of the present plant.

Directly behind these filters and on a mezzanine floor will be the conditioning plant.

At the present time it is intended to use liquid ferric chloride as a



General plan of the redesigned and enlarged sewage treatment plant at Hyperion. The existing buildings of the present screening plant are indicated in heavy dash lines.

coagulant. Received in cars, it will be unloaded from the siding near the beach and forced by compressed air to a storage tank located on ground of such elevation that the solution may run by gravity to the conditioning floor tanks. However, space for storage and convenient methods of handling have been taken into consideration, should it be desirable to use other types of chemicals.

In the engine room will be installed four 250 h.p. gas engines, directly-connected to electric generators; two 650 cu. ft. compressors; two vacuum pumps; certain other related apparatus and the main switchboard.

In close proximity of the northerly end of the filter building and the main switchboard, will be the proposed new transformer house into which will run the main overhead power lines.

Immediately adjoining the filter building on the east will be the dryer and incinerator building, enclosing three individual units capable of handling a total input of some 300 tons of sludge of approximately 72% moisture per day. The dryers will require a unit evaporation capacity of 8,000 lb. of water per hour and reduce the moisture content to at least 15%, if desired.

The pumping plant will be an under-ground structure, 30 ft. by 90 ft., equipped with 19 pumps. Ten of these pumps will be for the handling of sludge, three for low pressure wash pumps, three for high pressure wash pumps and three for hot water pumps. The main sludge pumps will be operated by program time switches and indicators, dials, signals and phones will advise the attendant of liquid levels and pressures in all lines and tanks under his control.

The present south screen plant building, 92 by 127 ft., is to be remodeled to accommodate a change room of the latest modern industrial type; a forge and machine shop with lathes, shaper, drill press, saws and other tools and equipment; a large wareroom; and a garage to shelter the private cars of employees. A new building will be erected with an attached garage to house the administration offices and the laboratory.

The plant is designed to treat an ultimate load of 130 m.g.d. and while plain primary sedimentation with chlorine odor control is initially contemplated, the arrangement is such that filtration and chemical treatment may be added, should further improvement in effluent be desirable.

The air from all tanks and buildings in which odor may be given off, as well as from the outfall sewer, will be drawn off by exhaust fans and passed through an odor removing medium.

It is proposed to park the grounds with drives, lawns, trees, and shrubbery, making the plant as attractive as possible and removing all features objectionable from a residential, bathing or recreational standpoint.

The new plant is being designed by the Sewer Design Division in the Bureau of Engineering, under the general supervision of Lloyd Aldrich, City Engineer.

TERMINAL ISLAND TREATMENT PLANT

Until 1933 the sewage from the San Pedro and Wilmington areas had been discharged at seven separate outlets into several different channels of the harbor and the bay.

With the exception of a small flow through a septic tank at West Basin and something over one second foot through an Imhoff tank into East Basin, this sewage was discharged raw.

To improve this condition, a general study of the entire situation resulted in the design of a series of intercepting sewers, pumping plants and force mains, to collect this sewage and convey it to a treatment plant on Terminal Island, with final disposal of the effluent through a submarine outfall into the bay. This system of sewers has now been constructed and the treatment plant while incomplete is being, I might say, broken in.

Sewage from the entire San Pedro area is collected at a point near 5th Street and Harbor Boulevard, then conveyed through a 20-in. cast iron siphon passing under the Main Ship Channel to the Terminal Way Pumping Plant, from which point it is forced through a 20-in. pressure line 4,200 ft. in length to the treatment plant.

In the Wilmington area, intercepting sewers discharge the entire flow into the wet well of the Fries Avenue Pumping Plant, it then being pumped to this same treatment plant by way of a 16-in. and 20-in. pressure line 9,300 ft. in length.



Terminal Island sewage treatment plant, designed for an ultimate capacity of 10 m.g.d., has primary sedimentation and separate digestion with sludge dried on sand beds and disposed of for fertilizer purposes.

Local areas on Terminal Island drain to either the Fish Harbor or Harris Place Pumping Plants, which discharge into the pressure lines, above mentioned.

It is to be understood that the Fish Harbor industrial sewage of fish

waste will be handled in an entirely separate plant and does not enter the domestic system at any point.

The Terminal Island Treatment Plant is located at the intersection of Ferry Street and Terminal Way, a point about 4,000 ft. northeasterly from Fish Harbor and 1,000 ft. back from the shore line.

Due to numerous and unavoidable delays, this plant has been in the process of construction since September, 1933, when the first contract was let.

As operation only commenced on September 1, there are naturally a number of unforeseen kinks to be worked out and neither the human nor mechanical machinery have had much of an opportunity to limber up.

Designed for an ultimate capacity of 10 m.g.d., the present flow is only 3.3 m.g.d. However, due to the fact that the entire flow is derived from four pumping plants via force mains, it initially receives very nearly ultimate peak flows of from 10 to 14 sec. ft. In fact, it is now receiving at times as high a peak flow as 18 sec. ft., the pumping plants having not as yet been synchronized.

The population served amounts to about 50,000 and the suspended solids normally run about 275 p.p.m., including 150 p.p.m. of grease. However, several fish packing plants in Wilmington are at times discharging as high as 22,000 p.p.m. of solids and 10,000 p.p.m. of oil.

The type of treatment is primary sedimentation and separate digestion, the sludge to be dried on sand beds and disposed of for fertilizer purposes.

A Wallace & Tiernan chlorinator with the necessary accessories has been installed at the Fries Avenue Pumping Plant for the purpose of odor control. Chlorine introduced near the pump suction will mix in the pump and pressure line giving the required residue on arrival at the plant. As those who visited the plant undoubtedly noted, this equipment has not been placed in operation.

The essential features of the plant consist of a clarifier and digester, three decantation tanks, a pumping plant, Parshall flume, gas and heating system, incinerator for burning rags, etc., sludge drying beds; the pumping plant building which includes the pump room, the boiler room, a work room, and the administration building, which accommodates the office, laboratory, change room, store room, shop and garage. These buildings are of frame stucco construction with concrete floors and foundations and tile roofs.

Due to the fact that the plant is located on land hydraulically filled, and with a high ground water level, all tank structures, which are of reinforced concrete, have been built above the ground surface.

Sewage reaches the plant by way of pressure lines. It first appears flowing from the diffuser at the center of the clarifier.

All pumping plants are provided with trash racks and a number of grit chambers are installed in the system, therefore the treatment plant is not equipped with these devices.

However, in the event of sand collecting to any serious extent in the feed or sludge lines connecting with the clarifier or digester, methods have been provided for its comparatively easy removal.

The clarifier is of the Dorr circular siphon feed type, 85 ft. in diameter, with 13-ft. sidewall depth, 16-ft. total depth and a freeboard of 1½ ft. It has a capacity of 600,000 gal. The raking mechanism is suspended from equipment mounted on a central pier and motivated by a 3 h.p. motor. An overload kick-off and electric alarm protect the machinery in the event of obstructions.

While under the present flow the tank has an average theoretical load rating of only 530 gal. per sq. ft. and a detention period of 4.8 hr., practically the load rating is nearer 1,200 and the detention period 2 hr.

Grease removal is effected by a skimmer attached to the perforated cylindrical baffle, which revolves with the raking mechanism. In order to bring the maximum amount of grease to the surface, a number of water jets under high pressure are introduced into the feed tube and carry down air, releasing it in fine bubbles near the bottom of the tube.

Sampling and measuring of the depth of the sludge blanket is accomplished by means of an aspirator connected to the high pressure effluent line. A suction hose with visible graduations may be lowered into the tank and the liquid material brought up passes through a detachable glass jar, where it may be observed or sampled.

The clarified effluent flows through a series of submerged ports and then over a weir extending around the entire periphery of the tank, and is collected by a launder. From this launder the effluent is discharged into a 30-in. cast iron siphon, conveying it to the Parshall flume.

The flume proper is designed with a throat 2 ft. in width and a length of 25 ft. and has a 25 sec. ft. capacity. The structure is mounted on piers, the flow line being 8 ft. above the ground level. This elevation was necessary in order to provide the head required to operate the submarine outfall extending 1,000 ft. off shore, and which may be later extended further.

The movements of a float installed in the stillwell of this structure are by electrical impulses transmitted to the Electro-Flow Meter instrument mounted on the main switchboard, indicating, recording and totalizing the flow through the flume.

The pumping plant is equipped with one Barnes adjustable, plunger type sludge pump, with a capacity ranging from 50 to 150 g.p.m., operated by a 5 h.p. motor, 2 Chicago screw-feed sludge pumps operated by Sterling and U. S. vari-speed equipment having capacities that may be varied from 50 to 150 g.p.m.; one Chicago two-port, closed runner sewage pump of 300 g.p.m. capacity, to the suction of which is attached Skidmore priming equipment; and one Byron-Jackson high pressure effluent pump with a capacity of 100 g.p.m. Overhead cranes permit units of this equipment to be removed for repair or replacement.

The floor of the pump room is depressed 3 ft. below the normal floor elevation, the pumps being mounted on concrete pedestals and surrounded by pipe rail and checker plate connecting cat-walks. Pump lines are carried on chairs seated on the depressed floor.

The system of sludge handling lines and valves, in connection with the pumps, are so designed as to give extreme flexibility in order to meet all practical functions of the plant, as well as certain experimental operation.

The decantation tanks, three in number, are circular, each being 16 ft. interior diameter and 30 ft. in height with sealed concrete covers and cone bottoms. Fourteen 3-in. decanting lines are tapped through the side walls at one- and two-ft. intervals, all draining to a launder at the foot of the tank where each line is operated by a plug valve. A system of collecting lines, provided with checks, gauze flame traps and explosion reliefs, will remove all gas emanating within the tanks and convey it to the incinerator to be burned with waste gas from the digester.

In connection with plant operation, these tanks may be used to decant raw sludge prior to its entrance into the digester, as a storage for digested sludge hydraulically displaced when pumping raw sludge into the digester, or, when directly removed by pumping, for secondary digestion and for experimental purposes.

The digester, a circular, reinforced concrete structure, 75 ft. in diameter with sidewall of 27 ft. and fixed cover, is also of the Dorr type. The raking mechanism and scum breaker are suspended from and operate about a central column and are motivated by a 2 h.p. motor. Heating of the tank is accomplished by the circulation of hot water through pipe coils in the usual manner. The capacity of the tank approximates 2½ cu. ft. per capita.

Advantage will be taken of the gas formed within the digester for heating the water in the circulating coils, heating the buildings during cold weather, for laboratory work and operating a small incinerator for the destruction of rags accumulated at nearby pumping plants.

A Bryant water heater, located in the well of the pump house building, provides the means of reheating water for the digester.

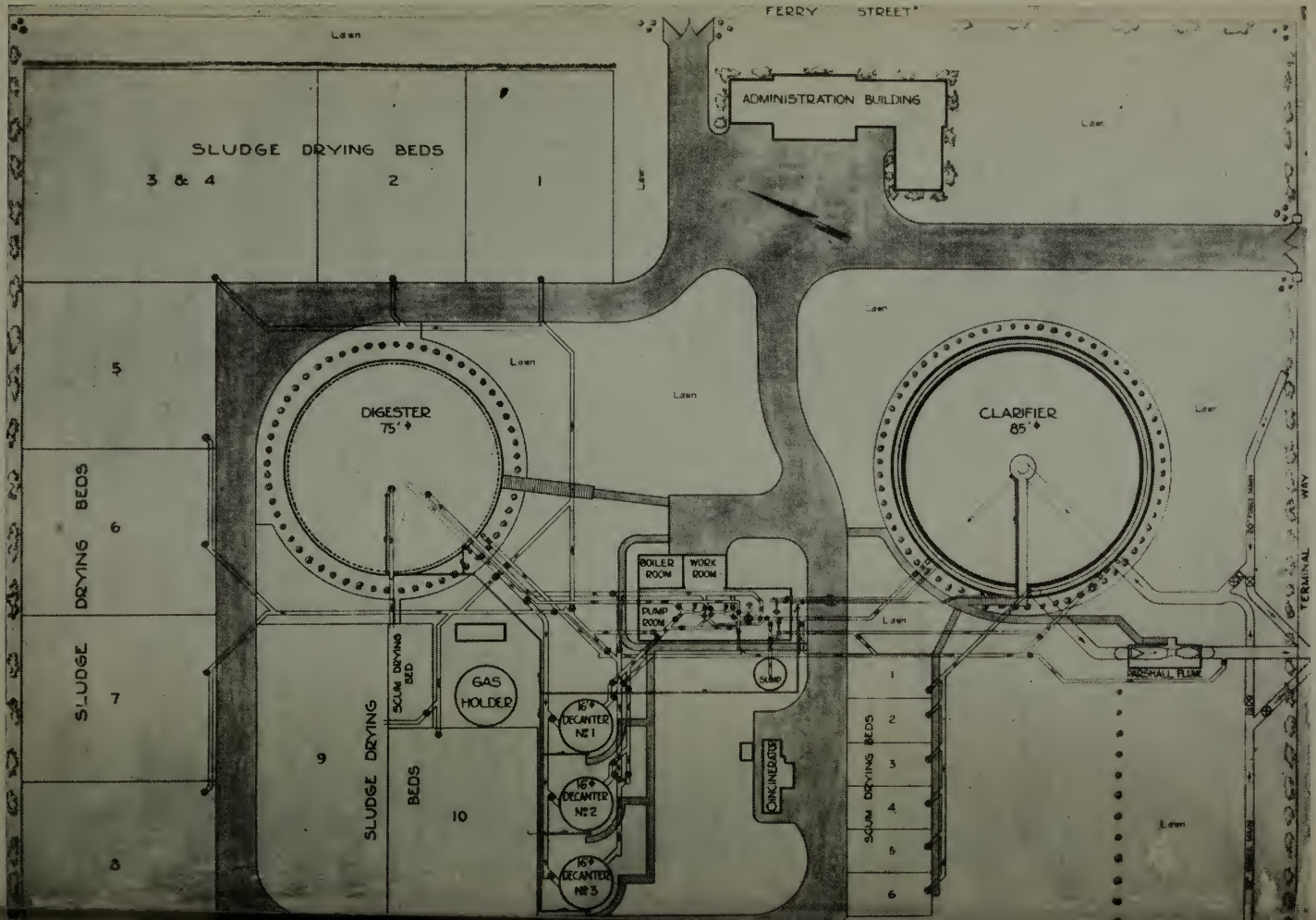
The main switchboard is installed in the pump room and, in addition to the light and power control switches, fuses and meters, there are mounted a Faraday type time clock on which a program may be set up for as long as one week, governing hourly operation of the sludge pumps; two Tork clocks, one operating the hour gong which may be heard over the entire plant, and one the obstruction lights on the steel floodlight pole which are required as the plant adjoins the new navy airport; the Electro-Flow indicating and recording instrument, in connection with the Parshall flume; and the water level indicator and recorder, in connection with the digester.

There will also be installed in the pump room a small air compressor for agitation, if desired, in the decanters and for laboratory, experimental and other practical uses.

In order that the digester may be heated during the so-called "breaking in" period, a 1,000-gal. oil tank has been installed and the boiler equipped with a forced feed oil burner. When the digester commences to furnish sufficient gas, this equipment will be replaced with a gas type burner.

The adopted method of breaking in has consisted in partially filling the digester with thin sludge and, from time to time, adding normal

Diagram (Page 43) of Terminal Island Plant which was designed for flexible operation to facilitate research for future plants.


FERRY STREET
Lawn
ADMINISTRATION BUILDING
SLUDGE DRYING BEDS
3 & 4
2
1
5
6
7
8
9
10
DIGESTER
75'ϕ
CLARIFIER
85'ϕ
BOILER ROOM
WORK ROOM
PUMP ROOM
SUMP
GAS HOLDER
SCUM DRYING BED
SLUDGE DRYING BEDS
16'ϕ DECANTER Nº 1
16'ϕ DECANTER Nº 2
16'ϕ DECANTER Nº 3
INCINERATOR
SCUM DRYING BEDS
1
2
3
4
5
6
ASPHALT PLANT
TERMINAL WAY

sludge to the mass. Meanwhile the preliminary gas and odor being given off, is passed through a "hot spot" made up of an enclosed checker brick grid heated by a weed burner to a temperature of from 1,500 to 1,800 deg.

The digester is provided with a Foxboro "Rotax" temperature indicator and controller, mounted on the roof. This apparatus controls the flow of warm water and preserves a uniform temperature in the tank. As was previously mentioned, a liquid level indicator and recorder on the main switchboard and also an indicator on the side of the tank, inform the operators at all times the water level within the digester. The instrument is equipped with an adjustable high and low-stage alarm which sounds on the switchboard.

Sludge entering the digester is metered through a tipping bucket, the operations of which are recorded on a counter. An attachment, in connection with the sludge meter, permits a sample to be automatically taken from each bucket.

Like the clarifier, an automatic kick-off and alarm bell protect the digester apparatus, should an obstruction block the operation.

The gas distribution system is somewhat different insofar as safety devices are concerned from the usual type of equipment, and in designing this feature of the plant, we adopted several types of apparatus that have been developed in the oil industry, for protection in the manufacture and handling of petroleum products that give off large quantities of highly explosive vapors and gases.

Briefly describing the system: leaving the gas dome of the digester a 4-in. pipe leads to the foot of the tank and enters the scum trap. This is simply a small tank 12 in. in diameter and 3 ft. high with a baffled gas outlet at the top and the scum outlet at the bottom leading into a U tube, which drains into the scum line. The tank of course remains filled with water to the top outlet of the U tube, but the gas does not pass through the water.

The 4-in. line continues to the meter pit. Here a Foxboro indicating and recording gas pressure gauge is connected, the line then entering the Blaw Knox Tracyfier, a device for removing moisture from the gas. It then passes through the Emsco meter which records the total flow. Just beyond the meter, connection is made with the 4-in. line leading to the gas holder. This tank has a capacity of 3,000 cu. ft., is of the water seal type and rides directly on the line.

Coming back to the meter pit, the line next passes through the Varec flame trap. This is a dry type of trap which has proven very successful in connection with refinery work. Next in line is a Varec explosion relief valve, the head being mounted just above the pit.

Between the meter pit and the regulator pit, a branch 2-in. line leads to the boiler room and the administration building. Reaching the boiler room, it passes through a secondary meter, then through a gauze flame trap, a swing check and finally to the burners beneath the boiler. The branch to the administration building passes through a Reliance type regulator and a gauze flame check before entering the building.

Returning to the 4-in. main line, as it enters the regulator pit a 1½-in. line branches off, passes through a low-pressure regulator, a gauze

flame trap and a swing check and runs to the incinerator where it feeds the burner. The main line, now reduced to 2 in., within the regulator pit passes through the main regulator, a Varec vapor recovery type, then through a gauze flame trap and swing check and to an escapement or waste gas burner in the incinerator. This burner is lighted by a pilot flame fed by a small line taking off from the main line, prior to its entrance into the main regulator.

All gas equipment is especially designed to resist sewage type of gases.

The plant will be provided with a series of sludge and scum drying beds with a combined area of approximately 42,000 sq. ft. As the soil is entirely sand and shell with occasional silt pockets, under-draining at this time is not considered necessary and the beds will be thoroughly worked over to a depth of 3 ft. and the top 12 in. removed and replaced with a classified coarse sand.

The beds are to be surrounded with concrete curbs and entered on ramps off of the adjoining paved drives.

As the plant is operated only during two shifts extending from 7 A. M. to 11 P. M., the remaining shift is covered by a watchman who punches a time clock from a series of stations at different points in the area.

The grounds comprising about 3 ac. are surrounded by an industrial-type wire fence 7 ft. in height, with ornamental iron gates and pylons. There still remains to be accomplished the contracts for the construction of the concrete drives, walks and curbs, the sludge beds and incinerator, and the parking of the grounds, including sprinkling system and the planting of lawns, trees and shrubbery.

The total cost of the plant proper will be about $175,000. Of this amount $72,000 had been spent prior to the receipt of authority for a 30% Federal grant, through the Public Works Administration.

The plant was also designed in the Sewer Design Division of the Bureau of Engineering, which is under the general supervision of Lloyd Aldrich, City Engineer.

DISCUSSION

Mr. Ribal: What disposition will be made of the screenings at the Terminal Island Plant?

Mr. Smith: The rags accumulated at the pumping plants will be collected into garbage cans and transferred to the treatment plant where they will be burned in the incinerator.

Mr. Ribal: Are there no screenings other than those on the coarse trash racks?

Mr. Smith: No. The screenings will all be taken care of at the pumping plants and these, together with the rags collected, will all be burned at the plant in the incinerator. No trash racks are necessary at the treatment plant.

Mr. Pomeroy: In the case of the Hyperion Plant: why was that means of drying—by vacuum filters and mechanical dryers—chosen, when drying on sand beds is so easily available and so much cheaper?

Mr. Smith: In the first place no one would stand for such a thing as sand-bed drying in that location. That type of sludge drying is a pro-

lific source of odors and when we planned to locate the plant down there it was specifically agreed that there was to be no odor nuisance. The Park Department is now endeavoring to extend the recreational beach from Hyperion to Del Rey and there is a thorough understanding that we are to have no objectionable odors or features of that kind.

Mr. Parkes: I should like to inject a comment on Col. Smith's paper. We have been operating the Terminal Island Plant only ten days. During this period we have had a little trouble with stoppage of the sludge pipes. There is high-pressure effluent available at the plant from a high-pressure pump which has a capacity of 100 g.p.m. When stoppages have occurred in the sludge lines, that high-pressure wash water has been a God-send. I can highly recommend a high-pressure wash water system for any treatment plant.

Mr. Rawn: Is the pumping system so arranged that you can backwash the sludge pumps?

Mr. Parkes: Yes. In most cases stoppages which have occurred have been removed by putting the water in one way or another, using the pressure on the suction side to force the stoppage on through—or if this wasn't practical we sometimes forced it back. Later on when the whole system is synchronizing, the rags, waste, etc., which come through will probably be reduced materially. At present they are not very effectively removed.

Question: Isn't the aeration of the sewage to remove the grease somewhat unnecessary? Wouldn't the grease settle to the bottom of the sludge digestion tank and make it unnecessary to try to float it off or otherwise get it out of the effluent? Have you made any type of investigation regarding that?

Mr. Parkes: As yet I have not. What you say may be true—maybe we are taking grease out of the sludge which would otherwise go to the bottom anyway. The important thing is that we feel we have reduced the grease quantity of the effluent. At the time experiments were conducted we did not have sedimentation in mind at all. They were made with the idea that the grease removal would be primary to screening. What we will find at Terminal Island, I don't know. We may find that we aren't doing the effluent any good. We have a manifold with eight nozzles pumping effluent into the sewage and carrying a considerable amount of air with it; the air foams and brings up a larger quantity of grease than our equipment is adequate to handle. However, we have always had this idea: that floatation of grease is one thing and sedimentation of sludge something else. Those two operations should be carried out in separate tanks. It seems that certain particles of the sludge itself are actually carried over the effluent which particles would settle without the addition of air. We may be taking out grease but also may be adding suspended material to the effluent. The operation should be carried out in separate tanks. We propose to try an extended set of tests which we hope will decide the matter.

PROPOSED IMPROVEMENTS IN SEWAGE FACILITIES FOR SAN DIEGO, CALIFORNIA

By B. D. PHELPS*

The City of San Diego surrounds a beautiful land-locked bay, 22 sq. mi. in area, that is used by commercial vessels, pleasure craft and as a base for the U. S. Navy. Along the shores at various points are well known bathing beaches. The outlet from the bay is through a channel that is now being dredged to a depth of about 45 ft. Tides provide a good scouring action through the bay, which has been the principal factor in helping an otherwise unsanitary menace.

The sewage of the City of San Diego, contributed by a population of over 170,000, presents a very interesting collection and disposal problem.

At the present time there are twenty-two outfalls serving San Diego; nine of these outfalls discharge into San Diego Bay, twelve into the Pacific Ocean and one into Mission Bay. All of the outfalls discharging into the Pacific Ocean have settling tanks and deep water outfalls. Two of the outfalls in San Diego Bay have settling tanks and the remaining seven outfalls discharge raw sewage directly into the Bay, including two from Coronado and two from Palm City.

The City of San Diego has recognized the need of a modern sewage collection and disposal system for years, and has at various times made studies of proposed trunk sewer systems and sewage outfalls.

During the years 1923 to 1929 a vast amount of street work and other improvements was at its height, property was assessed very heavily, and at the present time the City is burdened with assessments and will be for several years to come. Property can no longer stand assessments and it would be both impossible and impractical to hold a bond issue to finance new work. This has resulted in the present local condition of an increasing amount of sewage without any modern collection and disposal system.

The natural topographical features of the City and the present location of the existing trunk and lateral line sewer systems is a great advantage in establishing the main trunk line system of sewage collection along the ocean front and the San Diego Bay shore line. The City of San Diego owns a tract of land sufficiently isolated from the residential districts for the location of a treatment and disposal plant.

Sewage in San Diego is concentrated due to the fact that only 60 gal. per capita of water reaches the sewers. The City does not have large packing plants or other industrial plants. The gasoline wastes are separated from the sewage and thus it can all be classed as a domestic sewage.

The source of the sewage, until it reaches the proposed disposal site, would average 8 mi. and it would arrive in a fresh condition with the exception of that portion retarded in flow at the pump relift stations.

The treatment plant site is located so that the outfall will be short

*Assistant City Engineer, San Diego, Calif.

and end in water deep enough so that with multiple outlets proper dilution would be obtained in the Bay of San Diego.

The outcome of the various studies has been the following proposed plans, which have been submitted to the P. W. A. for a loan and grant of $2,000,000.

The project will consist of the construction of a pump house at the Marine Base that will boost the sewage into a 45-in. gravity line, which will eliminate the Old Town trunk sewer that now empties in front of the U. S. Marine Corps Barracks. The line will flow by gravity from this point south and intercept the large Olive Street sewer that now empties in front of Lindbergh Field and then continues with a 51-in. dia. pipe to Market Street, intercepting the trunk sewer at that point, and thence continue along the Bay front with a 63-in. dia. pipe, intercepting smaller trunk sewers until at Beardsley Street another relief pump-house will be required. The sewage will then flow by gravity through a 66-in. dia. pipe from this point to the sewage treatment plant near 32nd Street, and additional pumping will be required at this point.

The proposed treatment plant design will require considerable study due to the fact that water for irrigation is very costly in San Diego County and since a large number of lemon and orange groves are located to the south of San Diego, it may be possible to use all the water reclaimed for irrigation. This would, of course, depend on a cheap yet efficient means of treatment and sufficient demand for the water to warrant the installation of the required pipe lines. San Diego has its large Balboa Park which includes two golf courses, and while it would require considerable pumping and a dual system of pipes for irrigation, the future restrictions on the available water supply might make this a possible use for the reclaimed water.

In considering the design of the treatment plant, to date the following items were considered: The design of the plant would be for about 12 m.g.d. with space to increase the plant to 20 m.g.d. Approximately 75% of the City's sewage would ultimately reach this treatment plant.

The design would necessarily include a general building, containing coarse bar screens, also pumps of various sizes to control the lifting of the sewage from the sump to a sufficient height to cause a gravity flow through the other treatment tanks. The building would also include office and laboratory facilities, incinerator and space for filters, if used.

The plan at present would be to remove a large percentage of the solids and depend on the dilution of the bay waters for the final disposal. The plan would also include primary and secondary settling tanks so arranged that in the future chemical precipitation with return sludge could be practiced. Arrangements would also be planned so that a more complete treatment unit could be added, such as sand filters or a biological type process, if the water was required for irrigation.

The settled sludge would be removed to digestion tanks or to filters. The final product would find a ready market in the Park or in the orchards near by.

The City of San Diego is indebted to the State Board of Health and to the various manufacturers of sewage treatment machinery for the suggestions for the different designs that would be available if and when the plant is constructed. The City Engineer's office has made a careful study of the use of chemical treatment and separate sludge digestion, and before final plans are drawn it is the intent of the City to seek the advice of some reputable sanitary engineer to check all previous data obtained so that only the proper design for the specific purpose will be used.

The following is an itemized account of the P.W.A. project:

Sewage treatment plant		$ 516,050
Pump house (No. 1), complete	$48,727	
Pump house (No. 2), complete	60,067	
320-ft. double siphon	16,000	
		124,794
2,600 lin. ft. outfall 36-in. CI pipe	52,000	
42,235 lin. ft., 10-in. to 75-in. sewer	809,161	
113 Manholes	16,950	
1,300 cu. yd. pipe cradles	13,000	
		891,111
63,888 sq. ft. pavement		11,500
Contingencies		308,691
Preliminary expenses		20,000
Cost of rights of way		10,000
Engineering and architectural fees		80,000
Legal fees and advertising		37,854
		$2,000,000

DISCUSSION

Remarks at conclusion of paper:

"As I say, we are laying the field wide open and the City Council doesn't care to get into an argument. We took them on a trip to see the Plant. There was a dead whale out beyond, and as we returned the wind was against us and the whale overshadowed the treatment plant. They decided we didn't need a new one—just get the whale out of the way and everything would be all right. Someone has suggested that we wait awhile until that incident is forgotten and then take them out to the plant again. Mr. Goudey has been a very faithful friend of San Diego—as has Mr. Gillespie also. We have one of the finest bays in the country, but its pollution is a terrible condition. However, the layman doesn't quite see it, and until bonds are passed for the stream flow plants, I believe it will be impossible to get this work done. In asking for this $2,000,000 from PWA we hope to have something accomplished down there before all PWA money is let out."

SHIFTING THE TRICKLING FILTER INTO HIGH

By HARRY N. JENKS*

Synopsis

The sturdy low-gear power of the trickling filter for steady pull and for meeting temporary overload conditions has been amply demonstrated ever since its first engineering applications some forty years ago; but, with the increasing demands of modern sewage disposal practice, the need for speed and pick-up has become apparent. Accordingly, the efforts of many workers in this field have been periodically directed towards the release of this time-proven burden-bearer of biologic sewage treatment from its inherent limitations.

The work of the author, originating with the development of improvements in the design and functional elements of filters in the water purification field, and extending over a period of years in research studies on sewage filters, has shown that the trickling filter, in the form of the bio-filter, can now travel at from eight to ten times its former pace, with greater ease and higher unit efficiency than heretofore deemed possible. This unleashing of the trickling filter is strikingly similar to what occurred in the field of water filtration with the advent of the mechanical rapid sand filter, by means of which the output per unit area of filter bed was increased forty to fifty fold beyond the effective limits of the original slow sand units.

In its physical embodiment, bio-filtration assumes the structural form of the trickling filter plant, combined with the functional characteristics of the activated sludge process. Certain modifications of the bio-filter plant also directly parallel the functions and purposes of chemical precipitation. This merging of the processes appears to have overcome the major limitations, and to have united the chief advantages, of these established sewage treatment methods.

Viewed in its entirety, the complete process of bio-filtration is based on the principles of a free-flowing condition of the filter medium, recirculation of the effluent, and stage-treatment; all of these elements being inter-acting and of individual functional and economic significance.

The Condition of Free Flow Through the Filter Medium

It will be recognized that, as a starting point in any systematic effort to enable the trickling filter to operate at extremely high rates, the clogging of the filter material must in some way be obviated. In the author's experience this problem was met in a series of transitions from clogging to declogging to freedom from clogging.

From extensive laboratory studies and field observations the author has been led to the conclusion that clogging in a biologic filter is as much the result of anaerobic conditions as their cause. The maintenance of specifically high rates of flow through the bio-filter bed, whether of applied sewage or of mixed liquor, takes into account the foregoing theory of clogging. In addition to the actual flushing velocities accompanying high rates of filtration, the possibility of clogging is further forestalled through the assurance of a completely aerobic environment at all times and in all portions of the filter bed, by virtue

*Consulting Sanitary Engineer, Berkeley, Calif.

of the maintenance of a substantial dissolved oxygen reserve in the applied liquor and of abundant natural ventilation of the shallow filter bed, characteristic of the bio-filtration process.

In defining both the limitations and the order of magnitude of the factors of filter loadings and of velocities through the filter medium, the author has found it helpful to draw upon his experience in relation to rapid sand filtration, where the behavior of the gravel and sand beds of the filter, under conditions of filtering and of backwashing, suggest close and useful analogies to the hydraulic and mechanical phenomena associated with biologic filtration at comparably high rates. In 1930 the author presented a paper before the Wakefield (England) meeting of the Association of Managers of Sewage Disposal Works (1) in which he stated that

"Quite apart from biologic considerations . . . to one familiar with the engineering principles of water filter plant design, it is a natural transition to conceive of the applicability of the washing principle used in rapid sand filtration to meet the requirements surrounding the declogging of sewage filters. Some two years ago I proposed the use of a de-cloggable trickling filter, and designed a filter of this type for testing as to biologic sufficiency. . . . Contrary to what one might possibly expect, subsequent experience with the washable filter showed clearly that the backwashing did not at all adversely affect the biologic efficiency. Moreover, when such a filter was operated in series with a secondary trickling filter, it was demonstrated that the benefits of biologic stage-treatment were realized."

The fundamental conclusion drawn from the functional behavior of the de-cloggable biologic filter was that, since it was found that a 3-in. vertical rise of backwash was sufficient to cleanse the bed and still leave it biologically intact, similarly high rates of filtration could be expected to maintain the filter medium in a free-flowing condition, accompanied by undiminished, but rather enhanced, biologic activity. This deduction from previous experience has been fully corroborated in the operation of the bio-filter as subsequently developed by the author.

Regardless of the proportions of applied sewage and of filter effluent contained in the recirculated liquor, the author observed at the beginning of his work that the unprecedentedly high rates used by him, reaching as high as 125 m.g.a.d., fairly well established the free-flowing range of operation of the bio-filter. By "free-flowing" is meant a condition wherein the rate of passage of liquid through the bed is intermediate between flushing and flooding of the filtering material, and results in the bio-filter continuously unloading without impairment of its biologic efficiency.

The Practical Significance of Recirculation

To develop the maximum unit purifying capacity of the filtering material it is not enough merely to operate the trickling filter at high rates of filtration based on superficial area. The bed should be activated through the return of portions of the effluent. This also inherently serves to place the bio-filtration process on an activated sludge basis in respect to both the time and degree of aeration and consequent bio-

logic oxidation. The period of detention and recirculation, in hours, is analagous to that of activated sludge aeration. Through this introduction of a definite time element into the process, the bio-filter becomes dynamic instead of static as the trickling filter has remained because of its limitations.

High rates of filtration, accompanied by recirculation, accomplish the two-fold purpose of obviating clogging and of supplying the organisms with the abundance of food supply demanded by their greatly stimulated activities. It is now generally agreed that biochemical oxidation is largely the accompaniment of bacterial multiplication and is related only in a minor way with bacterial numbers (2). In other words, the rate of biologic purification appears to be more influenced by the condition of the biologic life than on its mere amount. The environment within the bio-filter bed is at all times conducive to an active condition of a relatively small volume of biologic jelly (zoöglea), and hence in a practical way fulfills the theoretical requirements for rapid biochemical oxidation.

This situation, however, imposes a further requirement which is nicely met by recirculation. This is the furnishing of an uninterrupted supply of biochemical oxygen demanding constituents to the organisms in order to enable them to do their work. It was found by Phelps and later confirmed by Streeter and his colleagues (3) that the rate of de-oxygenation in polluted water is directly proportional to the remaining concentration of organic matter, measured in terms of oxygen demand, and is, over a broad range, independent of the amount of dissolved oxygen present.

As pointed out by Kessener and Ribbius (4), the first part of Phelps' law carries with it the inference that the return of sludge in a biologic purification system has not only the function of furnishing the required microörganisms and adsorption surfaces, but is in addition a supplier of oxygen demanding constituents. The latter part of Phelps' law indicates that an optimum dissolved oxygen content exists in the presence of activated biologic life for efficient functioning.

In the bio-filter, it has been observed, greater efficiency results from a proper "loading" of the bed with oxidizable organic matter. The question of whether this loading should take the form of return sludge or of greater specific amounts of organic matter per unit volume of filtering material (i. e., higher rates of filtration and/or recirculation) is a matter inviting further research. However, it has been amply demonstrated that the latter means of loading the filter bed with the required biochemical oxygen demanding constituents for an activated condition of the organisms inhabiting the filter medium, is sufficient in itself without the return of sludge. It appears at the moment that the return of sludge in the bio-filtration process may well be of value, not so much to ensure the practical working of the system, as further to decrease its operating costs. This is one of several distinguishing features from the activated sludge process where the return of sludge is practiced not only to improve the efficiency of the method, but fundamentally to make the process work at all.

To summarize the foregoing discussion, the author has observed that

in bio-filtration there is an actual need of a B.O.D. supply, in order that the organisms may be furnished the required energy for all the work they are called upon to do. This is particularly true in the first stage of two-stage treatment, where the food supply should be relatively abundant in relation to the number of organisms, which, like a man doing hard physical work, require a correspondingly greater amount of food than when at rest. The environmental conditions found in the bio-filter and detention tank system favor the development of large numbers of active biologic forms, particularly protozoa, within a small space. Hence the rate of application of the sewage must be correspondingly high and/or the unappropriated food supply passing forward through the filter must be returned for more nearly complete consumption, by recirculating the filter effluent. This forced feeding of the activated protozoa and their friends and relations seems to fulfill a function in the bio-filter similar to mechanical stoking and forced draft combustion of modern high-pressure boilers.

The Principle of Stage-Treatment

It is well known that a definite zoning of the organisms of purification occurs in a trickling filter, from the top to the bottom. Broadly speaking, the top half of the bed is concerned with ammonification and the lower half with nitrification. Bio-precipitation takes place largely in the upper zone, the sloughings from which tend to clog the lower zone and/or impair ventilation through the filter bed as a whole. Good nitrification requires a longer period of detention in the system, which implies the need of a larger surface area of filtering material for this stage of oxidation. This theoretically calls for finer material in the lower and coarser material in the upper half of the trickling filter, attention to which was drawn by Buswell as a result of studies (5) in this field in 1924-26. The operating difficulty occasioned directly by physical clogging and indirectly by anaerobic conditions resulting from impaired ventilation stands in the way of grading a deep filter bed downward from coarse to fine filter material.

On the other hand, the author has found no practical engineering difficulty in taking the top half of an ordinary deep filter bed off the lower half and making a separate filter-stage of it, with coarse rock in the primary stage and fine rock in the secondary stage, and sedimentation of the filter sloughings after each stage; except that, from the cost viewpoint, stage-working or double filtration is not economical with the trickling filter. However, in the case of the high-speed bio-filter, with its consequently greatly reduced area and rock volume, coupled with shallow depths of filter bed, stage-treatment becomes not only entirely practicable but also tremendously increases the scope and versatility of the process itself. As an interesting and valuable confirmation of British experience in stage-working, where the application of effluent from a previous stage enables a subsequent stage to function effectively at high rates without clogging, comes also the present experience of the recirculation of the effluent, and concomitant activation and freedom from clogging, within each stage.

Another important advantage arising from stage-treatment is the possibility it affords of accommodating the rate of recirculation to

the actual biochemical oxidation requirements within the successive periods of ammonification and nitrification. The economic as well as biologic value of maintaining higher rates of recirculation in the first stage succeeded by lower rates in the second stage, is particularly apparent in the treatment of strong sewages and industrial wastes.

Elements of Bio-Filter Plant Design

Structural Elements

The engineering design of a bio-filter plant follows accepted procedure in respect to all major structural and equipment elements, a matter of importance in the application of any new development, from the standpoint of both the designing engineer and of the manufacturer of sewage works equipment.

The design of the bio-filter itself involves the use of a standard form of rotary distributor. The detention tank, provided with continuous sludge removal equipment, may be of either the circular or rectangular type best suited to the specific conditions governing the layout of any given plant. Finally, the requirements of operation entail the use of low-head pumping equipment of relatively high capacities. These conditions are ideally met by the characteristics of the screw or propeller-type pump of which several standard makes are available, having the requisite high efficiencies and mechanical dependability.

The Recirculation System

The recirculation system involved in bio-filtration can best be described by reference to the flow diagrams of Fig. 1. In general, this system is the connecting link between the bio-filter and the detention tank and furnishes the means whereby the liquid is repeatedly subjected to the biologic oxidizing properties of the activated filter bed, as the sewage is held in the tank for the required period of recirculation.

From the hydraulic point of view, the following typical arrangements of plant may be recognized:

Type A—Recirculation involving pumping from the bio-filter into the detention tank, with gravity return to the bio-filter.

Type B—Recirculation involving pumping from the detention tank onto the bio-filter, with gravity return to the detention tank.

An example of Type A recirculation is illustrated in Fig. 2, showing the bio-filter plant constructed for the Camarillo State Hospital (Ventura County, Calif.); while Type B recirculation is provided in the plant shown in Fig. 3, which furnishes irrigation water for the landscaping of the City of San Mateo (Calif.) sewage treatment works.

Recirculation Pumping Units

It is evident that the recirculation pumps become literally the "heart" of the bio-filtration process. This accomplishment is the fulfilment of a prediction made by the author in relation to the conception of mechanical aeration of sewage, when he stated in the paper previously referred to (1) that

"I have designated the means for producing mechanical aeration of the sewage as 'pumping equipment,' for I believe that ultimately the most economical and effective engineering applications in this field will be based on the conception of the matter as a pumping problem, sep-

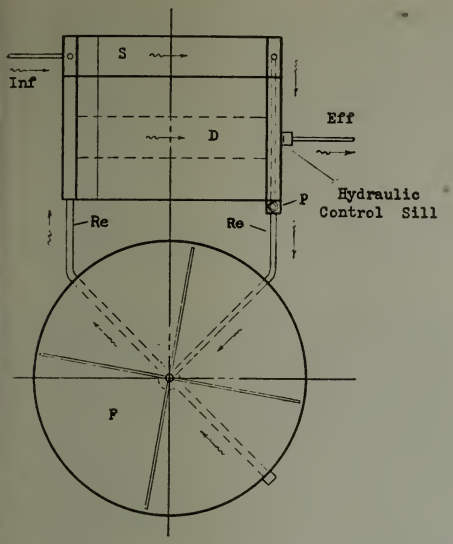


Fig. A. SINGLE STAGE (Complete Treatment)

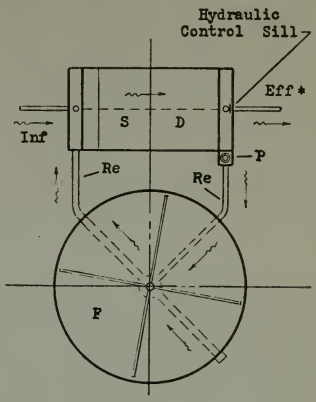


Fig. C. SINGLE STAGE
(Intermediate Treatment)

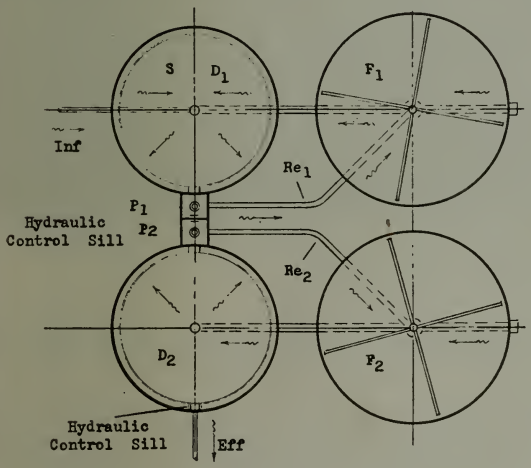


Fig. B. TWO-STAGE (Complete Treatment)

Note: Subscripts 1 and 2 refer to the primary and secondary stages, respectively.

Key to Abbreviations

S - Primary Settling Tank
D - Detention Tank
F - Bio-filter Bed
P - Recirculation Pump
Re - Recirculation System

Arrows indicate normal direction of flow.

* Note: Final clarifier may be required if sedimentation period in combined detention--settling tank becomes less than 1 hr., based on flow of recirculation.

Fig. 1.—Flow diagrams of recirculation system.

arate and distinct from mechanical agitation. . . . From the standpoint of power consumption, it is clear that the efficiency of the mechanism must remain low when an attempt is thus made to combine two opposing hydraulic conditions. The fundamental hydraulic requirement for efficient operation is that there shall be as little agitation as possible.

Accordingly, the two phases of aeration, namely recirculation and agitation (aeration), should be kept separate . . ."

This is precisely what has been attained in the design of the bio-filter system, where recirculation is treated purely as an hydraulic problem, and oxidation solely as a biologic problem, in each of which cases the governing conditions are well-nigh ideally complied with.

Range of Treatment

In relation to the design of a bio-filtration works, the introduction of the principle of recirculation into the operation of a trickling filter has

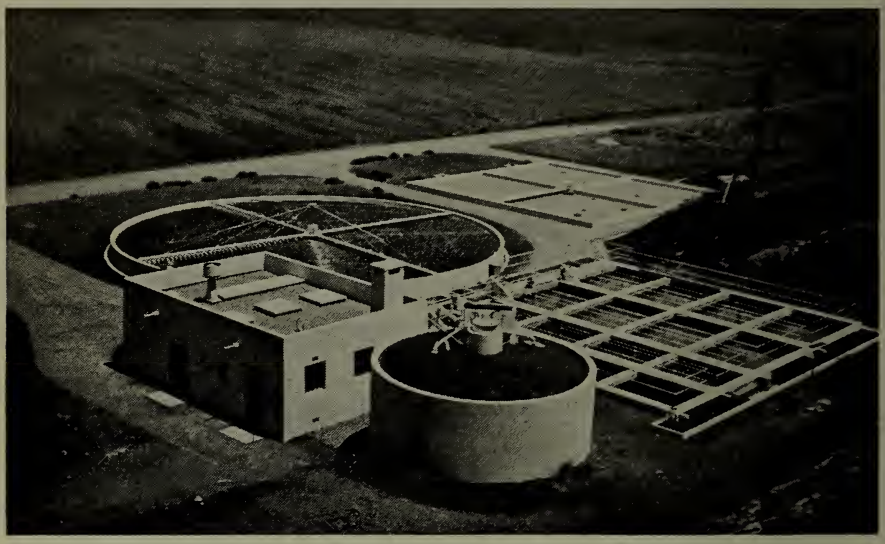


Fig. 2.—GENERAL VIEW OF CAMARILLO STATE HOSPITAL BIO-FILTER PLANT

Bio-filter bed 85 ft. diam., 3 ft. deep, provided with 1½-2½-in. filter rock, for single-stage treatment of strong institutional sewage. Primary settling tanks in right foreground.

the fundamental effect of liberating the filter from its basic limitations, generally recognized to be (a) Limited rates of filtration, (b) Limited degree of purification, and (c) Limitations due to odor and fly nuisance.

In like manner, variations in the rate of recirculation permit the adaptation of the bio-filtration process to the entire range of organic wastes treatment from plain sedimentation on the one hand to activated sludge results on the other.

Ordinarily, the volume of recirculated liquor is a multiple of the volume of sewage flow, but where high rates of filtration as such are alone required or permissible, then the ratio of recirculation rate to sewage flow (designated as Re/Q) may be reduced to unity and the material passing through the bio-filter bed comprises applied sewage

only, with no return of the effluent. This, of course, gives a lower degree of treatment than when recirculation is practiced.

Similarly, for a plant designed for a given set of conditions, the operator has at his command a means of controlling the quality of the plant effluent independently of a wide range of changes in concentration and/or volume of sewage undergoing treatment, by the simple expedient of increasing or decreasing the rate of pumpage of the recirculated liquor through the bio-filter beds. The pumping units may readily be made to respond automatically to such changes.

It is apparent from the results of practical plant operation that two-



Fig. 3.—CITY OF SAN MATEO IRRIGATION WATER RECLAMATION PLANT

Installation typical of two-stage bio-filtration, producing an effluent comparable with that of the activated sludge process. In this installation, the effluent is used for irrigating the landscaping of the municipal sewage treatment works.

stage bio-filtration is essentially one of complete treatment for sewages and organic wastes in general. It should accordingly rank with the activated sludge process in this respect. On the other hand, a broad field of usefulness for the bio-filter plant is discernible in its adaptability to produce any desired intermediate degree of purification of the final effluent.

In considering this aspect of the process it is of interest to note that bio-flocculation accomplishes a degree of purification resulting from the combined effect of sludge production plus biochemical oxidation. On the other hand, purification by chemical precipitation as such is limited largely to removals of organic impurities as manifested by sludge production only. Oxidation, and consequent stabilization, of the

liquid portion of the sewage is, by comparison, practically absent. There is a strong presumption that bio-filtration will be found to release the latent biochemical forces of the trickling filter so effectively as to place it on terms of functional and economic parity with chemical precipitation. Which process will be superior under any given set of conditions will generally depend on specific end-results and costs arising from:

(1) A relatively limited sludge production and large amount of exidation secured through bio-flocculation; or
(2) A relatively large sludge production and limited amount of oxidation effected by chemical precipitation.

In bio-filtration, use is made of the ability of the sewage organisms to elaborate their own biochemical reagents for the purification of the sewage, in contrast to the need for the artificial introduction of extraneously manufactured coagulants employed in chemical precipitation. By the simple expedient of recirculating the effluent a greater or less number of times through the bio-filter bed, the biochemical dosage, so to speak, required to produce an effluent of pre-determined quality, is varied to suit the conditions of optimum bio-precipitation. On the other hand, if this biochemical dosage is not so altered, the operation of the bio-filter is not thereby disrupted, the results merely becoming less than optimum.

Summary of Engineering Design Factors

Bio-filter plant operating data are available to serve as a basis for the development of a rational theory of engineering design (6), (7). The order of magnitude and the inter-relationships of the more important design and operating characteristics of the bio-filtration process are here summarized as a matter of interest to the members of this association. It should be understood, of course, that the numerical values in each instance are to be interpreted as merely typical and subject to modification in conformity with the local conditions under which any given sewage treatment works may be designed and operated.

(1) The economic depths (y) of bio-filter beds are between 2 ft. and 4 ft.
(2) For a 3-ft. depth, the economic range of rates of filtration (F) is from 18 to 24 m.g.a.d.
(3) Grading of rock sizes for biologic efficiency combined with free-flowing conditions:
 (a) Single-stage treatment, 1½-2½ in.
 (b) Two-stage treatment, 1½-2½-in. and ¾-1 in., for the primary and secondary bio-filter beds, respectively.
(4) Over-all purification per cubic yard of filtering material is independent of specific division of total rock volume between primary and secondary stages, within a range of 0.33 to 3.0.
(5) A progressive purification with time takes place in the process, the most rapid biochemical oxidation occurring during the initial period of 2 hr., and particularly during the first hour; which is strictly analogous to the oxygen-demand satisfaction curve of the activated sludge process.

(6) For complete treatment, the aggregate detention period should be from 4 to 6 hr.
(7) The economic limit of detention period (D) is 6 hr. for strong domestic sewage.
(8) In two-stage treatment, the per cent purification and the purification per cubic yard of filter material are substantially independent of the detention period within a range of 1 to 6 hr. The per cent relative stabilities are in direct proportion to the detention period.
(9) The quality of the final effluent is practically unaffected by ratios of primary detention period (D_1) to secondary detention period (D_2), ranging from 0.5 to 1.0.
(10) For complete treatment, the aggregate rate of recirculation (Re) varies from 2 to 5 times the rate of sewage flow (Q).
(11) Up to a recirculation ratio of $Re/Q = 6$, the removal of oxygen demanding constituents per cubic yard varies directly with the ratio of recirculation rate to sewage flow.

Economic Considerations

Capital Investment

Plant Site—For a given capacity, the bio-filtration works require a plant site of an area somewhat greater than that for an activated sludge plant, but less than one-quarter that needed for a trickling filter installation.

As regards the location of the site, it is probable that a bio-filter plant will require very little more plant isolation than is now deemed necessary for activated sludge installations. The immediate dilution of the applied sewage with the returned effluent, before being applied to the filter bed, tends greatly to minimize odors; while the high rate of recirculation, including specifically high rates of filtration, prevents the active development of insects, by drowning.

Construction Costs—Estimates and actual construction costs of bio-filter plants indicates that under comparable conditions a bio-filter plant, as a complete treatment process, requires a capital investment only somewhat more than for an activated sludge installation, and from one-half to two-thirds that of a trickling filter plant. Similarly, as an intermediate treatment process, a bio-filter plant will also compare favorably with chemical precipitation in first cost.

Costs of Operation

Except in cases of complete gravity flow through the plant, the major operating cost of the trickling filter is occasioned by the pumping lift between the primary settling tank and the dosing chamber. Similarly, the chief operating expense of an activated sludge plant is that of power for aeration and agitation of the sewage. Again, the chief item of cost for the chemical precipitation plant is for the sewage coagulant. Finally, the cost of operation of a bio-filtration plant centers in the power requirements for recirculation.

It appears that, in general, this power requirement is of the order of magnitude of (a) Double that for a trickling filter plant, and (b) One-half that for an activated sludge installation. These values are based

on the production of an effluent comparable, respectively, to that afforded by these standard processes.

Considerations of the inherent dependability and simplicity of operation of the bio-filter plant, which it shares with the trickling filter, warrant the conclusion that the costs of labor and supervision of a bio-filtration works will be found to correspond closely with those for a trickling filter installation.

Computed Power Requirements for Bio-Filtration

In the nature of the case, the power required for bio-filtration may be accurately computed in advance. From actual operating experience in general, supplemented where needed by specific tests, it is possible

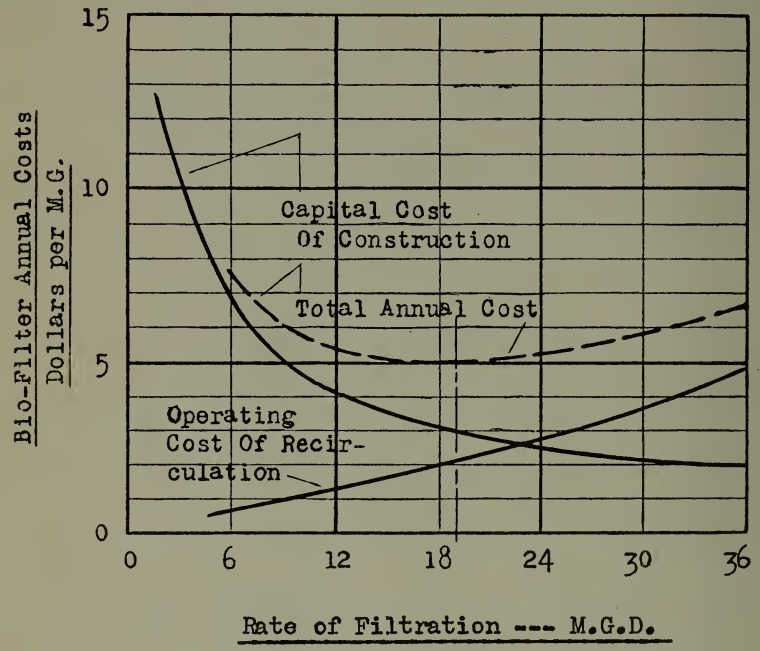


Fig. 5.- DIAGRAM ILLUSTRATING THE DETERMINATION OF ECONOMIC RATE OF BIO-FILTRATION

to determine within a narrow range the required or desirable recirculation ratio, Re/Q, which defines the aggregate pumping equipment capacities. The total head against which the pumps operate can be accurately determined by hydraulic computation. The over-all efficiency of the pumping units is known in advance on the basis of manufacturer's performance curves. These three factors completely define the corresponding power requirements.

As has been noted, the value of the ratio, Re/Q, varies directly with the required removal of oxygen demanding constituents per cubic yard

of filtering material. Similarly, in order to secure any desired degree of purification, in terms of residual B.O.D. in the effluent, the required rate of recirculation varies directly with the rate of working of the filter rock, in terms of the volume of sewage applied per cubic yard of rock per day. The higher the rate of filtration, the smaller the volume and cost of the bio-filter bed, and the greater the necessary rate and cost of recirculation. These two opposing conditions afford the oppor-

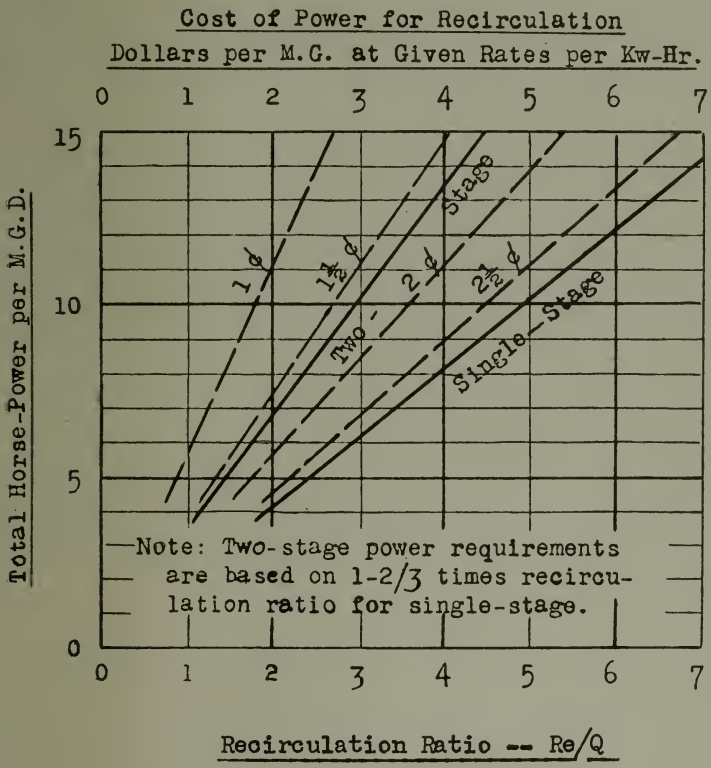


Fig. 6.-- POWER REQUIREMENTS AND COSTS IN RELATION TO RATES OF RECIRCULATION

tunity of striking an economic balance between the capital cost of construction and power cost of operation, in the design of a bio-filtration works. This is illustrated diagrammatically in Fig. 5, where, under the assumed conditions, the economic rate of filtration is seen to be 19 m.g.a.d., at which the total annual capital and operating charges are about $5.00 per million gallons treated.

There is also an economic depth of filter bed, related, not to the cost, but to the biologic efficiency of different depths, and based on cor-

responding costs of pumping against the static lift occasioned by such depths. The shallower the depth, the less the pumping head, but the less also the permissible rate of filtration; and hence the greater the required area of bed to secure a given percentage of B.O.D. reduction. However, an extensive study of the influence of filter depths and volumes shows that the economic depth of filter bed is limited to a comparatively narrow range in any event (for sewages), with a 3-ft. depth appearing to be a practical optimum, all things considered. Actually, tests, both at Palo Alto and at Salinas (Calif.) lead to the conclusion that in two-stage treatment, a certain advantage may accrue from the use of a depth of about 4 ft. in the primary and of 2 ft. in the secondary unit (the areas being equal); but for practical purposes it appears proper to make both bio-filters of an equal depth of 3 ft.

Taking, for example, a typical domestic sewage, and employing two-stage treatment for activated sludge results, a recirculation ratio of 3 and 2 may be assumed for the primary and secondary stages, respectively. The total pumpage per million gallons flow therefore becomes $(3 + 2) \times 1$ m.g.d $= 5$ m.g.d. $= 3500$ g.p.m. Assuming a depth of filter bed of 3 ft. and allowing for distribution losses together with friction and static head losses in the recirculation and underdrain system, the total dynamic head becomes, in practice, approximately 7.0 ft. Manufacturers of screw or propeller pumps are prepared to furnish units having over-all efficiencies of 60% or better, for the sizes involved in the design of full-scale municipal plants.

In the present example, the horsepower requirements per million gallons treated therefore becomes 10 h.p. With electric current at 2 cents per kw-hr., the corresponding cost per million gallons treated becomes $3.60. Power requirements and costs in relation to rates of recirculation are set forth graphically in Fig. 6, for both single-stage and two-stage bio-filtration.

Conclusion

The trickling filter is now in high-gear, and the open road of achievement in the biologic treatment of sewages and industrial wastes lies ahead. It remains to be seen how well the new bio-filter will avoid the soft shoulders of inefficiency, negotiate the sharp turns of pH and pollution, surmount the heavy grades of H_2S and B.O.D., respond to the stop-and-go exactions of fluctuations in sewage flow, and keep up with the steady traffic of year in and year out operation.

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DISCUSSION

Mr. Wilsey: In the presence of these authorities on sanitary facilities, sewage treatment and disposal, I would just like to say that we in San Mateo are delighted with the results obtained. The plant has proved that it will do all we expected and it is all that Mr. Jenks says. We keep some sewage in the tanks and the filters produce a very fine effluent. As Mr. Jenks stated, we have to post "Do not drink" signs on the hydrants. Even had a plumber who drank some of the effluent without bad results!

Mr. Kimball: We have been using the effluent from our sedimentation division and seem to have a lot of trouble with clogging in the primary filter distributor.

Mr. Jenks: Clogging is probably caused by the plant being too small and by the smallness of the holes in the rotary distributor. There would be no such difficulty in a full-scale plant installation.

Mr. Curry: Rates of filtration and rates of discharge on the beds. Is that the rate of dosage including the recirculation or the total flow?

Mr. Jenks: The rate of recirculation is usually some multiple of the filtration rate. The rate of flow through the plant may be from 20 to 24 m.g.a.d., based on the area of the bio-filter beds. Rates of application which result from the recirculation may be 40 to 60 to 80 m.g.a.d.

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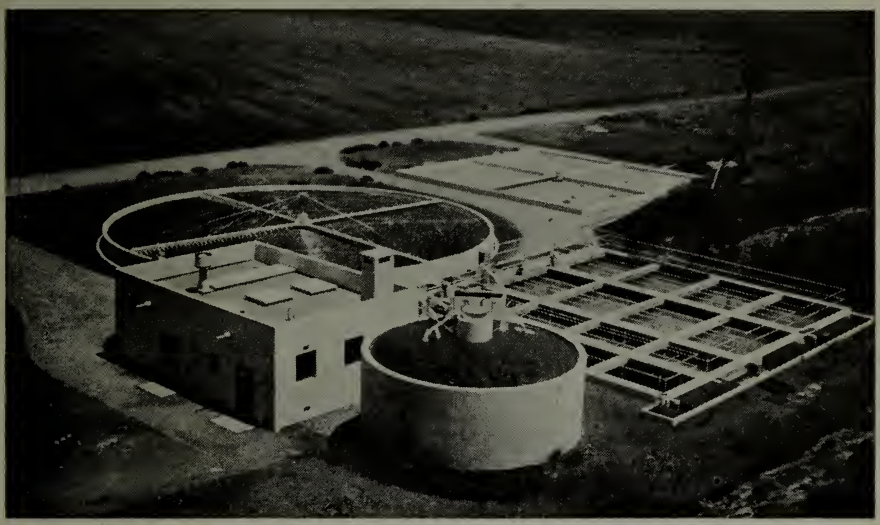
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CALIFORNIA SEWAGE WORKS JOURNAL

Official Publication of the California Sewage Works Association

Vol. IX :: 1937 :: No. 2

Minutes of the Ninth Spring Conference
at Stockton, California
April 23 and 24, 1937

•

Mechanical Filtration of Effluents

•

Cannery Wastes at Palo Alto

•

Sewage Disposal in the Pacific Northwest

•

Pollution of the Mokelumne River by Winery Wastes

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Plant Operator's Symposium on Mechanical Equipment



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NINTH ANNUAL SPRING CONFERENCE

Stockton, April 23 and 24, 1937

●

PROGRAM

FRIDAY, APRIL 23rd

Morning

8:00—Registration at Hotel Clark, Stockton.
8:30—Leave by caravan for Lodi Activated Sludge Plant.
9:30—Leave Lodi for Stockton North Disposal Plant.
10:45—Leave Stockton North Plant for South Plant.

Afternoon

12:15—Luncheon (jointly with Stockton Engineers Club).
2:00—Discussion of the plants visited.
2:15—Stream Pollution of the Mokelumne River by Winery Wastes by Paul A. Shaw.
3:00—Treatment of Effluents by S. I. Zack.
4:00—Operators Symposium on Mechanical Equipment by C. F. Tennant; J. H. Van Norman; R. C. White; A. W. Wyman; H. M. Ely; F. W. Post.
4:45—Adjournment.

Evening

7:00—Dinner, Hotel Clark.
8:00—Presentation of Award of Merit.
8:15—Bay Bridge and Highway Problems by Earl Lee Kelly, Director State Department of Public Works.

SATURDAY, APRIL 24th

Morning

7:15—Directors Breakfast.
9:00—Business Meeting and Committee Reports.
9:30—Cannery Wastes at Palo Alto by J. H. Kimball and Ted R. Gregory.
10:00—Sewage Disposal in the Pacific Northwest by Carl E. Green, Sanitary Engineer of State of Oregon.
10:45—Trip through the Los Angeles Outfall by R. F. Brown.

Afternoon

1:15—Caravan for Tracy and Monteca Plants.
2:15—Inspection of Tracy Plant.
3:00—End of Caravan.

Plants and Personnel Receiving the Annual Award of Merit Presented By the California Sewage Works Association

1936—San Bernardino
Bard Livingston, superintendent water department
L. A. Hosgood, engineer
William Berg, chief operator

1935—Palo Alto
J. F. Byxbee, city engineer
Jack Kimball, plant operator

1934—No award

1933—Yosemite National Park
Col. C. G. Thomson, superintendent
E. M. Hilton, park engineer
R. C. White, chief operator
Calvin Willette, assistant operator

1932—Salinas
T. R. Hazeltine, chief operator

1931—Pomona
F. C. Froehde, city engineer and chief of sewer department
B. S. Henry, chief operator

1930—Pasadena
A. W. Wyman, superintendent
W. A. Allen, assistant superintendent

1929—Davis—University of California Farm
John Jacobson, superintendent of buildings and grounds.

The annual award is donated by Wallace & Tiernan Company, Inc.

PROGRAM

Fall Convention

CALIFORNIA SEWAGE WORKS ASSOCIATION

San Jose, California

September 13-14, 1937

MONDAY MORNING, SEPTEMBER 13

A short tour of inspection is planned which will include a Santa Clara cannery, the new Santa Clara Treatment Plant, and the Los Gatos Imhoff-Trickling Filter Plant one of the oldest in the State.

MONDAY AFTERNOON, SEPTEMBER 13

All afternoon is to be given to a "Symposium by Operators, Engineers, and Equipment Men on Operating Problems" which should develop much valuable information. All members are urged to be prepared to discuss their particular difficulty and applied remedy.

TUESDAY MORNING, SEPTEMBER 14

The session will be opened by a business meeting and election of officers. The presentation of two papers will follow: one on "Electricity for Sewage Treatment Plant Operators", and the other on "Bacteriology in Relation to Sewage Disposal" both of which will furnish a fund of information on these important phases of plant operation.

TUESDAY AFTERNOON, SEPTEMBER 14

The afternoon session will be a joint meeting with the Engineers Section of the League of California Municipalities. Three papers are to be presented: One on "Uses of Activated Sludge Plant Effluent in Golden Gate Park" may answer the park water problem in localities where there is a shortage of water. The second paper on "Supervision of Plant Operation by the Designing Engineer" is intended to indicate how initial operation difficulties may be minimized and a basis for operation and maintenance established. The third paper "Charges for Sewer Connections from Outside Areas to City Sewer Systems" is in answer to a mounting problem on which considerable information has recently been collected.

MINUTES OF MEETING

Ninth Annual Spring Conference

CALIFORNIA SEWAGE WORKS ASSOCIATION

at the

Hotel Clark

Stockton, California

April 23rd, 1937

A luncheon was held jointly with the Stockton Engineers Club at the Hotel Clark. After the luncheon, a short speech was made by Vice Mayor Woodrow Coale, welcoming the Association to the city, which was replied to by E. A. Reinke, president of the Association.

The principal speaker of the luncheon meeting was State Engineer Edward Hyatt, who chose as his subject the Central Valley Water Project. In describing the project, he spoke of its long history and the many legal, political, technical, and human difficulties that have been surmounted since its inception in 1920. At that time, it became apparent that a shortage of water in the Central Valley districts made action imperative by the State of California. The legislature authorized an investigation of all water supplies in the state, and that was the first step leading to the project as we now see it.

Mr. McClure, Mr. Bailey and Mr. Hyatt successively State Engineers, conducted a thorough investigation from 1920 to 1931. The approval of at least a dozen Federal Agencies was necessary and was obtained.

The area to be served by this project is two-thirds of the irrigated land of California, and supports a population of approximately 900,000. An enormous agricultural industry will be made possible through the irrigation facilities of this project, and the rich mining centers will also be dependent on this water. The great industrial centers of the San Francisco Bay area and Metropolitan Los Angeles depend to a large extent on the Central Valley for their future prosperity.

In 1920 agriculture in the valleys had reached a state of stagnation and retrogression, due to the inadequacy of natural water resources. For a time wells were used successfully for irrigation but water was being taken out faster than the underground sources could supply the wells. The ground water table has been drawn down at the rate of 5 ft. per year for the past 20 yrs. until a stage was reached where it was no longer profitable for a farmer to irrigate his land from wells. Thousands of acres were abandoned, reverting to desert. The ensuing loss, both to the farmers and to the neighboring cities and the state in general, was the immediate cause of this investigation.

Mr. Hyatt then described the tortuous course of the project and the many attempts made to obtain the necessary legislation to give effect to the plan. In 1933 an act was passed, which authorized a bond issue to cover the cost of the project, subject to the obtaining of a 30% grant from the Public Works Administration. The voters approved this measure, but it was turned down by the Public Works Administration authorities on the grounds that sufficient revenues to cover the cost of

the project did not seem probable. In 1935 a favorable report was made by the War Department, which recemmended that the Kennett Dam be constructed as a flood control measure. Through the Emergency Relief Administration funds were made available for the dam as a reclamation project. Although financial difficulties at the present time seem to be under control, with plenty of money available, and more to be appropriated during the coming year, many other difficulties still remain.

The entire cost of the project is $170,000,000, and although only a small part of this amount is available at the present time, there is little doubt but that the remainder will be made available as it is needed.

Progress in an engineering project of this magnitude is necessarily slow. Many problems must be faced, perhaps the most difficult one being the opposition of power companies. The ultimate source of the revenue by which the bonds will be paid is from the sale of power that will be generated at the several dams included in the project. Naturally, the private utilities do not enjoy the thought of this competition. An attempt at conciliation seems to be under way, as both the Pacific Gas and Electric Company and the Southern California Edison Company are desirous of purchasing all available power at the source.

Mr. Hyatt closed his address by stating that he had every confidence that within the current year work would be under way at full speed on all portions of this huge project.

There was a short recess, after which the members assembled for the afternoon meeting.

TECHNICAL MEETING

Afternoon, April 23rd, 1937

The meeting was called to order by President Reinke in the Walnut Room of the Hotel Clark, at 2:35 P.M., April 23rd.

The president announced that the subject "Stream Pollution of the Mokelumne River by Winery Wastes" would be discussed by Paul A. Shaw. He said that while most of the members were familiar with one end of the winery business, probably not so many were familiar with the professional difficulties and that it would be of extreme value to them in case application were made to their City Council by someone wishing to discharge wastes into the sewerage system.

Following Mr. Shaw's speech there was a short discussion of the subject of winery wastes.

In reply to a question from Mr. Gregory, Mr. Shaw stated that while only a portion of the produce of a winery was made into brandy, most wineries put more material through the stills than is necessary for the manufacture of sweet wines.

President Reinke stated that he regretted that the time of this meeting did not coincide with the grape crushing season so that Mr. Ingram could have made arrangements for the members to inspect one of the wineries, which would have been interesting, instructive, and also entertaining. He remarked that, Mr. Shaw might have told more about the way wine is made.

Mr. Shaw replied that he did not go into the manufacture of wines because the DeMartini paper, a few years ago, had covered that fully.

President Reinke stated that the discussion of fungus growth in the wastes interested him though it had been discussed in a past meeting. He said that any sugar containing material seemed to be particularly good media for fungus growth, citing the experience at the Clarksburg sugar factory.

Discussion on Mr. Shaw's paper was closed and Mr. Reinke asked Mr. Henning if he would give a short description of the Lodi plant for the benefit of those who arrived too late to visit the plant.

Mr. Henning described the Lodi Plant as one of the pioneer activated sludge plants in California; originally put into operation in December 1923, and operating continuously since that time. The plant is preceeded by storage tanks, old septic tanks converted to this use, which give control of the return flow through the plant. Sewage at the point of treatment is septic, except at certain seasons of the year when storm waters enter the plant. The screen used is of the conventional Dorr type. The screenings are disposed of in bins and covered with earth for a short time. Until recently the plant utilized two aeration channels with a retention period of about 4 hrs. Three aeration channels are now being used. Conventional Dorr clarifiers are used for secondary settling. The influent is introduced into the clarifiers about 3 ft. above the bottom, using baffle plates at the discharge of the aerators. Effluent from the plant is conducted by pipe line into an irrigation district canal, and is used for irrigation of the various crops.

In reply to a question by Mr. Kimball, Mr. Henning said that the storage tanks had sloping bottoms, and were self-cleaning.

Mr. Ribal asked the cause of the strong odor noticeable at the plant that morning.

Mr. Henning replied that the odor was due to sludge drying beds becoming septic because of the abnormal rainfall and poor drying weather.

Mr. Schapp, attorney from San Francisco, asked Mr. Henning if there had been trouble at the Lodi plant over the Jones Patent, as at Milwaukee.

Mr. Henning replied that the plant had been in operation 10 or 12 yrs. before being notified of the infringement of patent rights and presentation of a claim for $14,000 royalty and damage. The matter was discussed with authorities at Milwaukee, and as a result it was decided a compromise would be cheaper than a lot of costly litigation. Negotiations with the holders of the Jones Patent resulted in a final settlement of slightly less than $1,000.

Mr. Henning, in reply to Mr. Sauer said the dried sludge is sold by contract to individuals and is then sacked and sold at fertilizer. For the last few years it has been shipped to the south.

Mr. Wyman asked what price was obtained for the fertilizer and Mr. Henning replied that the price was usually a lump sum—probably equivalent to about $1.00 per ton.

The president introduced Mr. S. I. Zack of New York.

Mr. Zack presented a paper illustrated by slides on "Treatment of Effluents", which dealt with the Dearborn plant, where a magnetite filter is used.

A short discussion followed Mr. Zack's presentation.

President Reinke mentioned Mr. Zack's bringing up the subject of the amoeba, stating the importance of members keeping abreast of the times. He said that since the Chicago epidemic, the nation has become amoeba conscious, but that in spite of all the good work chlorine has done it has not been possible to kill the amoeba with reasonable doses, but that it is hoped that filtration will control this health menace.

The meeting was then given over to a symposium on mechanical equipment.

Fred West, of Stockton, stated that the clogging of pumps with cans, wood, burlap, etc., carelessly allowed to get into the sewer was a constant source of trouble. A strip of burlap 8 ft. long was wrapped up in one of his pumps. At another time some 4 x 4-in. wood blocks had to be chiseled out of the pump impeller. To avoid this trouble he installed a screen which, it is hoped, will do away with the clogging of pumps.

Mr. West was thanked by the president, who said that he could always be depended on for some good constructive criticism.

Messrs. Tennant, White, Van Norman, Wyman, Ely, and Post presented prepared papers on this subject which papers appear elsewhere in this Journal.

Mr. Hoskinson, who did not have a paper prepared, gave a short talk on the equipment at the Sacramento pumping plant. The plant, originally a steam plant, was partially changed to electrical in 1922 when two of the old steam units were replaced by two 20-in. horizontal pumps operated by 60 H.P., 490 R.P.M. motors. These pumps gave trouble caused from clogging with rags and rubber tubes which unfortunately got through the 2½-in. opening of the bar screen. Previous to about 8 yrs. ago when the change was made in the impellers of these pumps, two or three cleanings a year were required to keep them operating but since that time satisfactory operation has been obtained with cleaning once a year, except when some chunks of concrete arrive at the pump.

At the close of the talks on equipment, President Reinke remarked that the association has been trying to get the interest of the operators, and that he believed that this symposium had accomplished the purpose. He suggested that the Program Committee for the Fall meeting arrange an open forum or debate in which Mr. Fred West might lead the operators and Mr. Kennedy the engineers. He said hearing from both sides would present a more complete picture than today's meeting, which featured only the one side.

In reply to a question from the president regarding bearings, Mr. Hoskinson said that he thought the vertical bearings were an abomination, and that he had had as much trouble as a 3-ring circus with the Marine type bearings. The practice has been to use a vertical pump with the motor carrying its own weight. The Marine type of bearing is gradually being eliminated. If the vertical type bearing must be used the Timken seems the best. Each bearing should have self-contained lubrication. Circulating lubrication systems cause more trouble with clogging, than the self-contained oiling system.

The meeting was adjourned at 5:30 P.M., when the president urged all members to attend the Association dinner at 7 o'clock that evening.

Saturday Morning, April 24th, 1937

The meeting was called to order by the president, in the Walnut Room of the Hotel Clark, at 9:15 A.M.

The president asked for a report from the membership committee. He explained that the set-up had been changed a little this year by relieving the secretary of some of his duties, and having the former secretary, Fred Bowlus, serve as chairman of the membership committee and collect the annual dues. He commended Mr. Bowlus for the fine job he had done.

Mr. Bowlus reported that he had sent out notices as usual, and that a month or so ago an S.O.S. was sent to committee members. In response, a number of members paid their dues. He stated that at the present time some 50 of those who were members last year have not yet paid their current dues. The fact that there is considerable turnover in membership, is to be regretted. At the present time 200 members have paid dues, which is something that has not occurred in past years at such an early date, and usually not before the Fall meeting.

The president stated that they would not have had such a fine report had it not been for the assistance of Mr. Bowlus. He asked for a financial report from Mr. Ribal.

Mr. Ribal reported all bills paid, and $198.50 in the bank. Taking into consideration $333.00 accounts receivable, the balance is over $500.00.

The president asked Mr. Jeff Smith to take a bow for his fine work in handling the financing of the journal.

Mr. Goudey was asked to give a statement of the present status of the committee on certification of operators.

Mr. Goudey explained that his committee was divided into two sub-committees—one on Certification and the other on Short Schools. At this time he was able to render only a progress report. He asked if anyone present had failed to receive an application blank approved at the Santa Monica convention. He offered as a reason the committee had not received a larger number of applications, due to the fact that members are allowed until September 1st to apply. After that date an oral or written examination will be required to secure the certificate. A sample certificate was displayed, and attention called to the seal in the left hand corner, and the fact that the name would be written conspicuously and artistically in the space provided, and that it would be signed both by the president of the Association and the chairman of the Certification Committee. He urged everyone desiring certification to get his application in.

In reporting on the short schools sub-committee, Mr. Goudey passed out pamphlets. He said that while the course falls short of a B.A. degree, it is equivalent to a 2 year college course. The time required to complete the course is up to the operator as the school will be continuous, and one may take as long as 10 or 15 yrs. to finish if he so desires. The plan is to mimeograph all material to be used in this course, and it will be available two weeks before the course starts. The courses will alternate between the north and the south. This is the first time

it has been possible to get a University interested to the extent of assuming all expenses and with no expense whatever to the Association.

Mr. Harold Gray was asked to work on plans for having a school started a year from next summer in the North. Mr. Gray made the following brief statement to be included later in the progress report of the committee. There is a good possibility, through taking advantage of Social Security funds, that a course may be established in the North next summer, perhaps a little different in form and content than is being given at the University of Southern California this summer, but giving particular training which will supplement or continue that which is being so well set up in the south as an experimental proposition. The matter has already been broached to Dr. Karl Meyer at the University of California, and he has been assured of the cooperation of the Engineering Department at Stanford. The north will be fortunate in having the experience of the group in Southern California as a guide in this particular field, plus the experience with two schools, one for sanitary inspectors and the other for health officers held in the north this past year. The north is quite confident a program will be worked out.

Mr. Ribal asked if the mimeographed notes would be available for those who do not attend the school, and Mr. Goudey replied that it would not be necessary to attend to get the notes.

President Reinke said he had made a hurried analysis of the papers presented during the last nine years, and reported as follows:

19 papers were presented on Sewers.
4 papers were presented on Trade Wastes.
19 papers were presented on Finances.
21 papers were presented on Laboratories or Research.
41 papers were presented on Disposal and Disposal Methods.
10 papers were presented on Odor Control.
29 papers were presented on Operation of Plants.
26 papers were presented on Description of Plants.
10 papers were presented on Miscellaneous Subjects.

A further analysis showed that the vice president, Mr. Goudey, had presented more papers than anyone else, having delivered 8, and Mr. Kennedy 7. Up to this meeting there have been 151 papers and 101 speakers, which shows a widespread participation of all members.

Mr. Batty was asked for a report of the safety committee, but he said that he had thought there was to be a new committee so they hadn't done anything but that they could be ready with a report at the Fall meeting. The president said they could consider themselves appointed, and that they should have received a letter already, to that effect.

Mr. Gray gave a short talk on a few of the things which were taken up at the meeting of the Federation of Sewage Works Associations held at the Engineers Club in New York in January of this year. He reported that the association membership had increased during 1936, and now totals 2,069 members with a circulatory membership of 2,459. In spite of increased membership the Federation has continued to operate the publication at a deficit. In 1936 the deficit was $225. The actual cost of the Journal is $6,600, net, or approximately $5.00 per member. Of the $2.00 dues paid to this association, $1.50 will go to the Federation, so the

members are actually getting $3.50 more than they are paying for. This is coming out of advertising receipts. In 1936, changes were made reducing the cost and improving the general set up. This was thoroughly described by Mr. Mohlman, who has done an excellent job in editing the Sewage Works Journal.

The Federation Journal advertising has increased consistently during the last three years. There were as many as 17 pages in 1930, which dropped to 10 in 1932 and 1936 increased to 20⅔ pages.

It was also brought out at this meeting that 1938 would mark the 10th anniversary of the Federation. It was decided that a committee should be appointed to take care of some form of recognition of the fact of this ten years of existence. The following three suggestions were made:

First: A special meeting might be held in connection with the Fair in New York City in 1939. (Discussion indicated this to be too much of an undertaking.)

Second: A joint meeting might be held with the American Public Health Association in 1938.

Third: No special convention, but instead a manual of sewage works operation somewhat similar to the American Water Works Association manual might be prepared and printed. This seemed to appeal to most of the members of the Board of Control.

The cost was estimated to be about the same for holding a convention or printing a manual. The final choice will probably be the manual because of its greater appeal and more permanent value.

The President announced he had received an invitation from Long Beach to hold the next Spring meeting there.

Mr. Ribal reported a telephone call from the Chamber of Commerce of Oakland in which they also asked for the spring conference, and that Oakland asked to be present at Stockton with the necessary brass and drums but were discouraged as this has not generally been done.

The President said that the chairman of the Santa Barbara Convention Bureau was in Stockton at the present time, and that he also had approached him on the subject of having the convention in Santa Barbara.

The president introduced Mr. J. H. Kimball and Mr. T. R. Gregory, who had prepared a paper, jointly, on "Cannery Wastes at Palo Alto". This paper was presented, with the aid of a chart which was placed on the wall, and referred to during the talk.

Following this presentation there was a short discussion among the members, and a few questions were cleared up by Mr. Kimball and Mr. Gregory, on this subject.

Mr. Carl E. Green, Sanitary Engineer of the State of Oregon, then presented a paper on "Sewage Disposal in the Pacific Northwest". During his talk Mr. Green mentioned that the County Health Unit in Yakima, Washington was one of the first in the United States; that the State of Oregon (of which Portland has ⅓ of the population) is well provided with sewage treatment plants. There are 10 in the cities of the state, 3 in Indian Reservations, and one at a County Farm, and there are septic tanks in about 20 or more cities. The industrial waste

situation in the northwest is of interest because of the large amount of pulp and paper manufactured in Washington and Oregon; also there are five large sulphite mills along the Willamette River and its tributaries. The industrial waste of Salem is contracted for by the state for the prison.

Mr. Green stated that they had made a start but there is yet a lot to do. Only 10% of the waste in the northwest is at present receiving treatment, but they hope to get more treatment before it is too late.

Following this talk there was a short discussion on sulphite and its effect on the fish areas in the northwest. Mr. Gray mentioned an article in the Federation Journal by the Research Committee, which discusses this particular phase of pollution together with certain fermentation processes which are yet only in the experimental stage. Mr. Green remarked that the University of Washington had done a lot of research work in the field of sulphite wastes.

Mr. Hoskinson read a telegram from the City Manager of Sacramento in which he extended best wishes to the Association from the Capitol city, and further stated that they would be glad to have the Association meet in that city at any time.

Dr. Sippy, San Joaquin County Health Officer, was introduced and gave a short talk, in which he seconded the remarks of the Mayor of Stockton made the night before at the dinner. The Health Department, he said, represents four incorporated cities of San Joaquin County, as well as the rural area. Some of the smaller cities have been encouraged to provide proper sewage treatment for their communities. He said that since Manteca and Tracy were both on the way to San Francisco he would like to urge the members to stop and look over the plants at these two cities, as it would be a means of encouraging them.

Dr. Sippy expressed a hope that Stockton would have the opportunity of entertaining the members again, and that they could then show the association a little more progress in the way of sewage disposal in the area.

The President introduced Mr. R. F. Brown, who discussed a "Trip Through the Los Angeles Outfall". His remarks were well illustrated by slides.

Following this lecture, the President reminded the members that there were pamphlets available which would be of particular interest to those who had questioned Mr. Zack in regard to the Magnetite Filter.

The meeting was adjourned by the president at 12:30 P.M.

DINNER MEETING

Friday Evening, April 13th, 1937

The members of the association assembled at 7:00 P.M. Friday evening for dinner in the Hotel Clark.

The president announced that the members of the association were guests of the City of Stockton at the dinner, and that the mayor of the city, Mr. Ralph Fay, was present to add his word of welcome to that given at the luncheon meeting by the vice mayor.

The mayor gave a short address of welcome, in which he stated he had made a special effort to be present, especially when he heard that Mr. Kelly was going to speak.

In response, President Reinke thanked the mayor for his words of welcome. He expressed appreciation to the local committee, consisting of Mr. Ingram, chairman, Fred West, Fred Post, Lyle Payton, and Kenneth Brown, for the fine job they did in arranging the program.

President Reinke recalled the history of the association briefly by stating that it was formed in 1928 and grew steadily until the depression when it took a sag. The association now has a membership of 250, of which 136 are registered at this convention accompanied by 27 guests. There are 152 members and guests present this evening.

The five members of the association, Chas. Gilman Hyde, C. G. Gillespie, Harold F. Gray, Alexander Bell and R. R. Ribal who went to the conference in New York, were individually introduced by the president.

After receiving the history of the Award of Merit, President Reinke introduced the chairman of the award committee, Mr. Harry Hommon.

Mr. Hommon announced that the committee had unanimously recommended that the award go to the City of San Bernardino. The award was presented to Mr. Livingston who accepted it in behalf of the City of San Bernardino. Congratulations were extended to the operators and the San Bernardino delegation on the good work they had done during the past year at this plant. Mr. Livingston replied with a short talk, giving a review of the happenings of the two years the plant has been in operation under his supervision. He then introduced Mr. Berg, the chief operator, Roy Cox and C. A. Foletta, members of the Board of Water Commission and Mr. Currie the designer of the plant, that they might share in the honor.

Following the presentation of the Award of Merit, the president introduced Mr. Earl Lee Kelly, Director of the State Department of Public Works and guest speaker of the evening.

Mr. Kelly gave a very interesting address on the subject of "Bay Bridge and Highway Problems". First he touched upon the subject of the Central Valley Water Project, stating that he had recently been to Washington himself working on this project. This $170,000,000 project, he said, is the largest contemplated in the state today, and it is primarily the work of engineers. He said he often thought when the rains came down in the spring of the year causing floods, that something should be done to harness these waters and put them to work for a good purpose. The rapidly receding water table in the San Joaquin Valley requires that this project be expedited. So here is another great dream of the engineers really coming to fruition. He said, "I am quite mindful I am talking to men who have made our country what it is today. I wish to pay tribute to you gentlemen of the engineering profession. This great problem of the metropolitan area challenges men to do better things."

Coming to the highway subject, Mr. Kelly stated that California has 14,000 mi. of state highways, and we are prone to brag about them, being

the best in the United States. However, he said, California is eight to ten years behind in construction projects necessary to take adequate care of the present traffic.

In building the Bay Bridge, Mr. Kelly stated, it was not necessary to import a group of engineers. A group of 300 men and women from various communities throughout California designed and constructed this bridge, and set two world's records in so doing. Construction of the tunnel through Yerba Buena Island called for a larger bore than had ever been attempted; also concrete was successfully placed 242 ft. under water, a greater depth than it had ever been placed before. An idea of the magnitude of this engineering feat might better be visualized by the fact that 30,000,000 board feet of lumber was used to build the temporary work, enough lumber to build 3,000 modern 5-room bungalows. The lighting system is also a new development and consists of Sodium vapor lights which are cheaper than older types and have a fine penetrating value in fog. The 922 sodium vapor lights on the bridge provide light equal to 35 full moons.

In regard to the gas tax Mr. Kelly said: "It has been my policy and the policy of this administration not to stand for the diversion of the gas tax for purchases other than highway maintenance and highway construction. If we are going to take it to greater heights we must stand upon that policy of no diversion in the future for purposes other than highway maintenance."

In speaking of accidents on the highways, Mr. Kelly said a very small percentage of them were caused by faulty highway construction. In 1936, statistics show three principal causes accounting for 60% of the accidents: 24% were caused by improper passing (mostly on two-lane roads). One must know his own speed, know the speed of the vehicle he is passing and be able to judge the speed of the vehicle coming towards him, and even then if his judgment is bad, disaster will result. About 21% of the accidents are due to driving while drunk; 15% are due to excessive speed (which though not a primary reason is a contributing factor); 80% are caused by the condition of the driver. In 1936, 36,000 deaths were caused from automobile accidents in the United States. California's share was more than 1/12 of all the accidents, and more than ⅓ of these occurred in the city of Los Angeles. More and more is being done to make the highways safer in every way. One method of eliminating accidents is by changing the route of the main highways so that they do not pass by schools or shopping areas in the small towns.

Mr. Kelly closed by stating that one of the finest things about his job has been the opportunity of meeting so many fine people, making so many friends, and exchanging ideas with them.

The above stenographic notes include the information heretofore published as the secretary's minutes.

R. R. Ribal
Secretary-Treasurer

MECHANICAL FILTRATION OF EFFLUENTS

By S. I. ZACK*

INTRODUCTION

Sewage is composed of impurities in the form of suspended, colloidal and dissolved solids of organic nature. When discharged into a river or other receiving body of water, unless the currents are swift enough to carry them on, the heavier suspended solids settle out in the immediate vicinity and the finer solids farther downstream. The colloidal solids coalesce and coagulate and finally may also be subject to settlement. Such deposited solids, together with organic matter in solution, are subject to putrefaction if not supplied with sufficient oxygen to permit aerobic stabilization or oxidation.

The extent of nuisance created depends on the rate of decomposition as against the available forces of oxidation. Conditions are aggravated when sludge deposits, accumulated in a confined area, have remained stagnant during the winter period of biologic inactivity, and suddenly become subjected to rapid decomposition with the higher temperatures and lower dilutions of the summer period.

PURPOSE AND GENERAL METHODS OF SEWAGE TREATMENT

The purpose of sewage treatment is to remove impurities or change their chemical or biologic state so that the natural forces of oxidation of the receiving body of water can adequately act upon the residual products in the effluent before nuisances are created. Until recently modern sewage treatment generally comprised:

Primary Treatment, involving the removal of visible solids, accomplished by grit chambers, screening through slotted or bar screens and sedimentation.

Secondary Treatment, accomplished by some form of biologic oxidation such as activated sludge or trickling filters. In secondary treatment, the colloidal and non-settleable solids are coagulated to a point where they can be readily separated and removed from the liquid.

Secondary sedimentation provided the means for separating solids from liquid before discharge of the final effluent. Since the reaction is reversible, these solids may again break down into putrefactive forms, in the absence of sufficient oxygen. The amount of such suspended solids escaping furnishes one of the measures of the quality of the effluent.

There has been a wide gap between treatment afforded by primary and that which was possible by secondary methods, especially when measured in terms of dilution water required for the disposal of these effluents without nuisance. Revival of chemical treatment and the development of automatically cleaned effluent filters has placed new tools in the hands of sanitary engineers for the purpose of providing intermediate degrees of treatment.

*Sanitary Engineer, Filtration Equipment Corporation, New York City.

INTERMEDIATE TREATMENTS

Chemical treatment coagulates the colloidal and finer suspended solids so that they readily separate from the liquid and can to a large extent be removed by settling. As much is therefore accomplished with respect to these solids as in biologic methods, but chemical treatment falls short in the actual treatment of impurities in dissolved form. The oxygen required to stabilize a chemical effluent therefore is greater than for a biologic effluent but is much less than for primary effluents.

Mechanical effluent filters or strainers, with which this paper deals at considerable length, provide the other important tool. Effluent filters afford a direct means of treating and improving either primary, chemically treated or final biologic effluents by straining out solids that fail to settle. Several types of effluent strainers have been advocated or used for treating effluents. These consist of modified gravity-type water filters, with sand or crushed coal (anthrafilt) filter medium, designed either for rapid back washing, or utilizing various types of surface or subsurface washers, string discharge rotary vacuum filters, using paper pulp as a filter aid, and the automatically cleaned, thin bed, upward or downward flow Laughlin magnetite filter.

Attempts to filter raw or settled effluents, without chemicals, by means of gravity-type water filters, using standard size sand, have met with little success. Known experience in this country indicates permanent clogging. However, Dr. Mahr in Germany has reported some very interesting data covering a period of nine months on experiments, with a coarse grained rapid backwash type gravity filter, for straining settled effluents. Rather complete removal of settleable solids at 0.82 gal. per sq. ft. per min. filter rate was obtained on 1 to 2 mm. sand. This was considered the most satisfactory rate of operation since the efficiency of the filter was appreciably reduced as the filter rate was increased; and further reduced by an increase in size of sand grains used for filtering. Time between washings to reach a 4.1 ft. loss of head at a rate of 0.82 gal. per sq. ft. per minute was 25 hours, filtering through 2 to 3 mm. sand. At filter rates of 1.47 through 1 to 2 mm. sand, backwashings were about every 8 hours.

Experiments have been conducted at Atlanta, Ga., York, Nebraska and San Diego, Cal., on filtering chemical effluents by means of some modified forms of gravity-type rapid backwash filter. Both sand and crushed coal were tried at Atlanta. Effective removals of suspended solids were accomplished, but concentration and character of suspended solids in liquor that could be applied and rates of filtration were limited by the frequency of backwashing required.

Data have been prepared by Alexander Potter to show the average results of experiments on sand filtration of chemical effluents at Atlanta. The results indicated that 37 p.p.m. of suspended solids were removed from an influent of 45 p.p.m., and 26 p.p.m. out of 34 p.p.m. suspended solids, when using "anthrafilt" as a filter medium. These tests indicated filter runs of 12 hours at rates of 2.0 gal. per sq. ft. per min. and runs of 3 hours at rates of 3.5 gal. per sq. ft. per min., to develop less than 5 ft. loss of head. The range of suspended solids in the effluent applied to the filter was from 9 to 75 p.p.m. Compara-

tive data also indicated that twice as many backwashings were required for filter influents of 57 p.p.m. as for 18 p.p.m. suspended solids. The filter medium had an effective size of 0.45 mm. No relation was found between filter rates of ratio 1 to 4 and suspended solids removal. It was concluded in these tests that for filtration of chemical effluents carrying in excess of 75 p.p.m. suspended solids particular attention must be given to backwashing facilities.

Rapid backwash type filters are installed in small plants for operation on activated sludge effluent at Grand Canyon National Park and Barrington, N. J., but no information is available on performance or frequency of back washing over any extended period.

The most comprehensive and complete data on performance over continuous extended periods suitable for design purposes are available from pilot plant size and full scale plant operation of automatically cleaned magnetite filters.

DESCRIPTION OF THE MAGNETITE FILTER

The magnetite filter consists of bed of magnetite ore about three inches thick supported on a fine mesh of phosphor or silicon bronze (non-magnetic) wire. Fine suspended solids contained in primary or secondary settled effluents are caught between the particles of ore thereby clarifying these liquors in their passage through the bed. When the spaces of interstices between the grains of ore become partly choked with the intercepted solids, the filter is automatically washed by a cleaner which passes slowly over the ore.

The cleaner consists of a bottomless box or caisson which carries a centrifugal pump, and a solenoid or electro-magnet. The solenoid is alternately magnetized and demagnetized so that a narrow strip of ore is intermittently lifted off the wire screen and allowed to fall back. At the same time the small centrifugal pump maintains a head level which causes the liquor from beneath the bed to rush through the moving ore and effectively clean the portion of the bed lifted and agitated by the solenoid. The wash water containing the impurities from the ore is caught up by the pump and passed back for retreatment or other disposal.

This filter is adaptable for upward or downward flow filtration. In upflow it is usually supported on brackets on the inside rim of circular tanks. A number of plants using this type of design are either in operation or under construction. Upflow filters can also be designed for rectangular sedimentation tanks. The downward flow magnetite filter is a new development and was first demonstrated at Coney Island by means of a small circular filter. More recently this principle has been applied to a rectangular arrangement with reversal of the cleaning mechanism. An upflow filter within a tank provides a uniform distribution of effluent take-off over a large area, thereby retarding upward velocities. Such factors as the following, however, often make the downflow filter a desirable unit:

1. Flexibility of the filtering unit separated from the settler.
2. Size of grain not limited by the practical minimum screen opening as in upflow, because unfiltered liquor first reaches the washable filter medium.

3. Higher efficiency of removal possible with finer grain.
4. Filter medium washed with filtered liquor.
5. Less limitation on maximum loss of head, making possible somewhat higher filter rates.

MAGNETITE FILTER INSTALLATIONS

The installations of magnetite filters in operation or under way are shown in Table I.

The pioneer plant to employ the combination of chemical treatment and magnetite filters is at Dearborn, Michigan. This plant has been in operation since 1932 and uses chemicals throughout the year.

The Perth Amboy plant, originally designed for chemical treatment during the entire year, now finds it necessary to use chemicals only during the summer months. The filter, therefore, functions as a strainer on chemically precipitated liquors during the summer and on plain settled effluent during the remainder of the year. This type of seasonal chemical treatment is also to govern the operation of plants at Lakeland Institution, Camden, N. J. and Elmira, N. Y., which are already in operation and at Denver, Colorado and the Minneapolis-St. Paul Sanitary District, which are under construction.

Filters at Goshen, Ind., and Chillicothe, Ohio, strain the effluent from plain settling tanks. Columbus Grove, Ohio, Atlanta, Ga., and Southerly Plant, Cleveland, will use filters for polishing off the trickling filter effluents. At the Southerly Plant, Cleveland, partial activated sludge precedes the trickling filters and magnetite beds (downflow) in separate structures following the trickling filters. In this case the effluent filters are substituted for humus tanks. In the other installations the humus tanks, preceding the effluent filters, have been reduced in size.

The magnetite filters at Denver, Minneapolis and Cleveland are downflow in a separate structure, whereas, the others are upflow built on the inner periphery of the settling tanks.

All the plants except Denver have magnetite of 0.85 mm. grain size. The Denver magnetite will be about 0.60 mm. Finer magnetite was chosen to provide an additional safeguard in the re-use of the final effluent for irrigation, particularly because it is believed this size will strain out dysentery amoeba.

Performance on activated sludge effluent was demonstrated in a seven months test, from June, 1934, to February, 1935, with a 3 ft. wide upflow filter on a 20 ft. diameter tank at the North Side Plant of the Sanitary District of Chicago.

Greece, N. Y. now has under construction two 4 ft. wide upflow magnetite filters in 35 ft. diameter final activated sludge settling tanks.

Comparative tests were made at Coney Island (1934 to 1935) with two tanks in parallel, one without and one with a filter, both on plain settled and chemically precipitated effluents.

The use of magnetite filters for trickling filter effluents was investigated experimentally at Atlanta in 1935.

Tests with a circular downflow filter carried on during 1936 were recently completed at Coney Island. Similar tests are now under way

TABLE I.
STATUS OF MAGNETITE FILTER INSTALLATIONS

City	Date Placed in Operation	No. of Units	Width of Bed, Ft.	Size of Tank or Structure	Type of Service	Flow M.G.D. Each Unit	
						Design	Present (Approx.)
Upflow—Circular Filters							
Dearborn, Mich.	March 1932	2	8	60 ft. diam.	Chem. Treat.	8.00	3.00*
Perth Amboy, N. J.	June 1935	2	12	80	(Chem. Treat. 3 mo.) (Plain Sett. 9 mo.)	10.00	4.00*
Lakeland, N. J.	July 1936	2	3	21	(Chem. Treat. Plain Settled)	0.75	0.30
Goshen, Ind.	Sept. 1936	1	6	45	Plain Settled	1.75	1.50
Columbus Grove, Ohio.	Nov. 1936	1	3	21	Trick. Filter Eff.	0.50	—
Chillicothe, Ohio.	Nov. 1936	2	5	42	Plain Settled	3.00	1.00
Elmira, N. Y.	March 1937	2	8	60	(Chem. Treat. Plain Settled)	8.00	—
Atlanta, Ga.	Under Constr.	1	12	100	Trick. Filter Eff.	14.00	—
Greece, N. Y.	Under Constr.	2	4	35	Activated Sludge Eff.	2.00	—
Downflow—Rectangular Filters							
Denver, Colo.	Under Constr.	6	12	200 ft. long	(Chem. Treat. Plain Settled)	54.00	—
Minn.-St. Paul, Minn.	Under Constr.	8	16	245 ft. long	(Chem. Treat. Plain Settled)	134.00	—
Cleveland (Southerly Pl'nt)	Under Constr.	3	16	225 ft. long	Trick. Filter Eff.	40.00	—

*One clarifier and filter in operation.

with a small rectangular downflow filter to check the applicability of important features of mechanical design.

OPERATING AND ANALYTICAL RESULTS

Table II. shows overall efficiencies of filtration through magnetite filters, with and without chemicals.

Chemical costs to coagulate the sewage have ranged between $4.00 and $5.00 per M.G. at Dearborn and about $8.00 per M.G. at Perth Amboy. Perth Amboy sewage is highly industrial and very variable in character. In the course of a day pH of the raw sewage may vary from 2.0 to 9.0.

Results at Goshen were obtained by a special test supervised by Mr. E. Hurwitz, Sanitary Chemist, Chicago, in cooperation with the City of Goshen and Mr. Walter Bemis, Consulting Engineer. During the first part of the test serious surging occurred due to intermittent operation of a 3 m.g.d. capacity pump which started and stopped about five times an hour, running only a few minutes each time. Improved results were obtained by continuous operation afforded by a 1.5 m.g.d.

TABLE II.

RESULTS ACCOMPLISHED BY PLANTS WITH MAGNETITE FILTERS

Overall efficiencies of filtration through magnetite filters

Plant	Period	Flow M.G.D.	Chemicals used Lb. per M.G.		Suspended Solids			B.O.D.		
			Lime	$FeCl_3$	Inf.	Eff.	Pct. Red.	Inf.	Eff.	Pct. Red.
Chemical Treatment										
Dearborn ...	1935	2.7	224	307	388	22	95	189	40	79
	1936	2.4	160	208	339	27	92	185	51	73
Perth Amboy	July-Aug. 1935	2.8	659	252	240	28	89	257	100	60
Non-Chemical Treatment										
Perth Amboy	1935 (10 months)									
	1936	3.8			223	65	71	205	144	30
Goshen	Nov. 27, 1935									
	Jan. 8, 1936	1.3			206	76	63	152	80	47
	Jan. 4-8, 1936	1.4			181	58	68	139	65	53
Chillicothe* .		1.0			417	80	81	580	215	63

*Average of a number of grab samples in December, 1935, and January 1936.

At Chillicothe the plant routine has not yet been established, and the results included are from scattered grab samples only, but serve as an indication of the efficiency of settling and straining a very strong domestic sewage.

Analyses of samples below the screen in the upflow type, and of the influent to downflow filters, compared with analysis of effluents, furnish a basis for estimating the suspended solids actually removed by the filter. These results summarized in diagrammatic form are shown in Fig. 1. The removals for each type of effluent fall along the different straight-line curve and are proportional in each case to the solids reaching the filter.

Comparative tests were made at Coney Island between a 6 ft. diameter tank equipped with magnetic filter and another tank without a filter. In the non-chemical tests, it was found that about 20 per cent higher removal of suspended solids was obtainable by filtering after 2 hours of sedimentation. It was also learned, on that particular type of sewage, that 60 per cent removal was possible by settling 1 hr. followed by straining, as compared with 45 per cent by settling alone for 2 hours.

With chemical treatment it was found that $3.00 per m.g. expenditure for chemicals in the plain settling tank accomplished the same suspended solids removal as a filter-equipped tank without use of chemicals. Ninety per cent removal of suspended solids was obtained

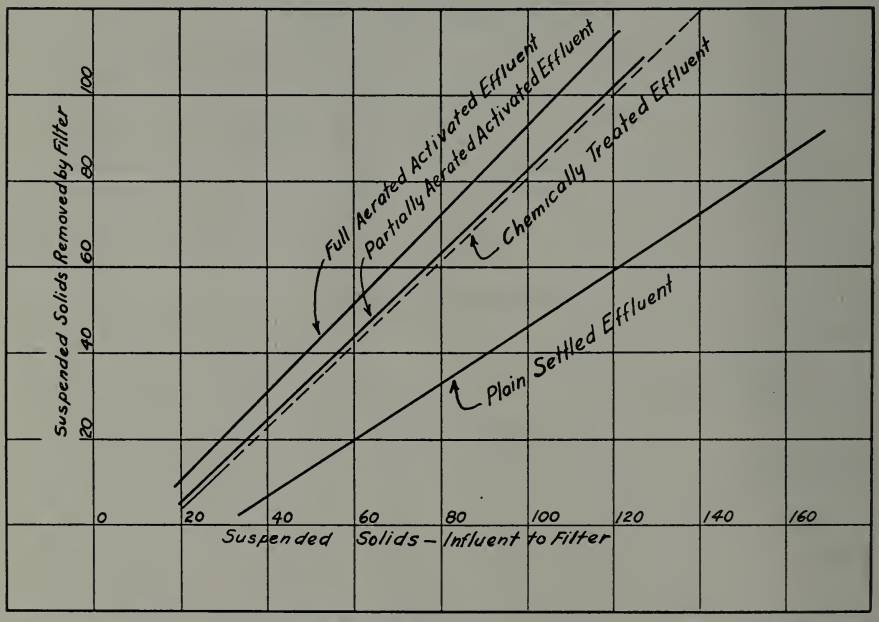


Fig. 1—Curves showing relation between suspended solids reaching magnetite filter and that which is removed. For straining various effluents.

by settling and filtering, at a cost of $6.00 per m.g. for chemicals, whereas $12.00 per m.g. was required to obtain the same treatment in a tank without a filter. For the same amount of chemicals a higher degree of treatment was obtained by the tank with a filter. Chemical

costs are based on lime at $12.00 per ton and $FeCl_3$ (anhydrous) at $40.00 per ton.

These data are significant because similar conclusions may be drawn from data by Damoose for experiments at Grand Rapids. The Grand Rapids data show that the filtered effluent contained 5 per cent less suspended solids after coagulation with 0.75 grains per gallon $FeCl_3$, figured at above price to cost $2.15 per m.g., than was obtained without filtration with 1.5 grains per gallon ferric chloride, amounting to $4.30. The Grand Rapids results were obtained with a shallow filter bed strainer, which was frequently washed by hand.

Data reported by F. M. Veatch on test results obtained at York, Nebraska, with a small gravity type backwash filter, indicate that after coagulation with chemicals, worth $4.35 per m.g., with settling for 4.3 hours in primary and 5.7 hours in secondary settling tanks, the settled effluent, carrying from 28 to 100 p.p.m. suspended solids, was further reduced to a range between 8 and 26 p.p.m. by the filter.

Continuous filter rates at the plants in operation have not as yet reached the design capacity. Data on filter rates are, however, available from pilot plant operation and for brief periods on a large scale. Rates of 2.0 to 2.25 gal. per sq. ft. have been found most suitable for continuous operation of upflow filters on a normal settled sewage, but there is no marked deterioration in the quality of effluent for temporary rates up to about 3 gal. per sq. ft. per minute. The filter has been operated at rates as high as 6 gal. per sq. ft. per min., but frequent washing by one cleaner covering a relatively small area was required.

Magnetic grain sizes ranging from 0.4 mm. to 4.0 mm. were tested in a small circular downflow filter. The best effluents, averaging as low as 30 p.p.m. suspended solids, were obtained with fine magnetite at a 2 gal. per sq. ft. per min. rate. As the grain size or rate of filtering was increased the quality of effluent decreased. Very substantial removals were obtained, however, with coarse magnetite and high filter rates. Under this condition it was necessary to make a complete cleaning of the filter bed every twenty or thirty minutes.

CHLORINE DEMAND OF FILTERED EFFLUENTS

An average reduction in chlorine demand of about 18 per cent was obtained by filtering out approximately 50 p.p.m. suspended solids. The raw sewage averaged 158 p.p.m., the settled unfiltered effluent 100 p.p.m., and the strained effluent 50 p.p.m. As much as 20 to 30 per cent reduction in chlorine demand was obtained by straining the settled effluent. On weak settled effluents the reductions in chlorine ranged from zero to 15 per cent.

COSTS OF MAGNETITE FILTERS

Contract prices of magnetite filters for installations bid separately from any other equipment, are shown in Table III. It is estimated that the annual cost, including fixed and operating charges for a plant of about 10 m.g.d. capacity, would be about $1.50 per m.g.

Estimates of operating costs indicate that magnetite filters will remove solids at a lower cost per ton than any other method in the same range of treatment. For example, on a raw sewage containing 200

p.p.m. suspended solids, 90 per cent can be removed by the activated sludge process at a cost of $35.00 per ton, or $26.00 per m.g. The magnetite filter makes it possible to remove about 15 p.p.m. more. The cost for removing the additional 15 p.p.m. is only about $25.00 per ton. A trickling filter, operating at $26.00 per m.g. removes 85 per cent of the suspended solids, at a cost of $37.00 per ton. Twenty p.p.m. more is removed by a magnetic filter at a cost of only $18.00 per ton, for the additional removal. Similarly 50 per cent of the suspended solids can be removed by plain sedimentation, at a cost of about $30.00 per ton. The magnetite filter takes out 40 p.p.m. or 20 per cent more at a cost of $9.00 per ton for the additional suspended solids removal.

TABLE III.

COST OF MAGNETITE FILTERS

	No. of Beds	Total Area Sq. ft.	Design Capacity M.G.D.	Contract Price Installed*	Remarks
Goshen, Ind..	1	735	1.75	$14,500	Upflow in circular tanks
Chillicothe ..	2	1160	3.0	27,700	Upflow in circular tanks
Denver	6	14700	54.0	255,150	Downflow fine magnetite with rectangular in separate structure
Minneapolis-St. Paul...	8	31230	134.0	516,390	Downflow coarse magnetite with rectangular in separate structure

*These figures show the additional cost of adding magnetite filters and supports, or separate structures.

CONCLUSIONS

1. Magnetite filters are operative on plain settled, chemically precipitated, activated sludge and trickling filter effluents.

2. Rates from 2 to 4 gal. per sq. ft. per min. are workable on downflow fine grained (0.60 mm.) filter beds and 2.5 to 6.0 gal. per sq. ft. per min. on coarse (0.85 mm.) beds when preceded by at least 1.0 hour of settling.

3. Effluent filters are economical from the standpoint of: positive savings in chemicals to accomplish a definite treatment, possibility of reducing size of tanks, production of a uniform effluent, improvement of preliminary or secondary effluents to prevent secondary deposition of solids in streams. All of these advantages may be difficult or costly to obtain by other methods in the same range of purification.

CANNERY WASTES AT PALO ALTO

By TED R. GREGORY* and JACK H. KIMBALL*

The cannery waste problem was realized directly after the Palo Alto Sewage Treatment Plant was put in operation on July, 1934. During each succeeding canning season the load on the plant has exceeded its designed capacity. The result of this overloading is indicated by an inferior effluent discharged into San Francisco Bay.

During this time it has been our opportunity to observe and to run preliminary laboratory tests on the cannery waste and to note the effect on an otherwise domestic sewage. The purpose of this paper, therefore, is to present as fully as possible our observations on the cannery wastes and their effect on the operation of the treatment plant; to enumerate preventive measures taken by the city to reduce the load upon the plant; and finally to show the strength and character of the cannery waste in comparison to the normal domestic sewage as indicated by the laboratory results.

SUMMARY OF PALO ALTO SEWAGE TREATMENT PLANT

Before starting on the subject of this paper, a brief summary of the quantity and character of the sewage, and the type of treatment employed at the Palo Alto Sewage Treatment Plant will be given.

Quantity and Character of the Sewage. The average sewage flow for the past year has been 1.66 m.g.d. from a contributing population of approximately 20,500. The maximum flow has reached 3.00 m.g.d. which is the designed capacity of the plant. The character of the sewage during eight months of the year is purely domestic. The Sutter Packing Company operates four and one-half months of the year and is the only industry contributing trade wastes to the sewage plant. During the 1935 season this cannery packed the following quantities of products: spinach, 1,200 tons; apricots, 960 tons; peaches, 5,000 tons, and tomatoes, 3,300 tons. The cannery operates from eight to twelve hours a day and employs a maximum of 500 men and women. On a full day's run approximately 500,000 gal. of water are used.

Type of Treatment. The Palo Alto Sewage Pant is the plain sedimentation type with separate sludge digestion. Plant equipment includes a ¾ in. mechanically cleaned rack, three 1100 g.p.m. sewage pumps which lift the sewage 24 ft., and a 151,000 gal. circular clarifier. The clarifier has a theoretical retention period of 1 hr. at the maximum designed rate of 3.00 m.g.d. The sludge is pumped to a 386,000 gal. concrete digesting tank with a fixed cover. This tank is provided with heating coils and maintains the sludge at a temperature between 90 and 100° F. The piping is arranged so that the contents can be circulated by the sludge pump. The final disposal of the effluent is by dilution in San Francisco Bay 1,000 ft. off shore. Sludge is disposed of by drying and pulverizing for fertilizer in the city's parks.

EFFECT OF CANNERY WASTE ON PLANT OPERATION

Soon after the plant was placed in operation, the operator was faced with the problem of freeing the clarifier of large quantities of halved and

*Operators, Palo Alto Sewage Plant.

sliced peaches. The peaches, being at the fermentation stage, floated on the surface and at times reached a depth of two feet. The skimming device was naturally inadequate for such a load and consequently the peaches had to be removed by the slow process of hand skimming. During this peach canning season the operators were kept busy practically day and night at this work. The peaches were skimmed into the skum trough from which they went to the sludge pit and were then pumped to the digester along with the raw sludge drawn from the bottom of the clarifier. Tomato season followed the peach season, and as all waste tomatoes were washed down the sewer, the plant was soon flooded with tomato skins. The skins, in contrast, settled to the bottom of the clarifier and were pumped to the digester. Since the tomato skins are not affected by the process of digestion and being lighter than the sludge, they formed a dense mat from two to four ft. thick on the surface of the digester and are still there after two years. Seven months after the plant was put in operation the contents of the digester had become ripe enough to begin active digestion. For the next three months a great deal of foaming was experienced along with extremely high gas production, the average for the tenth month of digestion being 38,430 cu. ft. with a maximum daily production of 52,000 cu. ft. which was equivalent to 2.5 cu. ft. per capita. It is reasonable to believe that this tremendous activity prolonged over a three months' period may be blamed on the large quantities of peach waste. The thick mat, formed by the tomato skins on the surface of the rapidly digesting sludge, probably prevented a smoother digestion operation. During this first year, therefore, operation of the plant was made extremely difficult due entirely to excessive cannery waste.

Since the writers were not connected with the plant during the first year of its operation the following information covering this period was obtained from the paper written by Harvey O. Banks and published in the January 1936 issue, Sewage Works Journal, which was presented at the Fall 1935 meeting of this Association.

PREVENTIVE MEASURES AND THEIR EFFECTS

It was believed that a large part of this canning waste could be prevented from entering the sewer at the cannery itself. Therefore, cooperation of the Sutter Packing Company was asked for by the City Engineer. There is a city ordinance for the purpose of regulating all wastes discharged into the city's sewers. However, reference to this ordinance was not necessary as the Packing Company cooperated to the fullest extent in the attempt to prevent solid wastes from entering the sewer. In this respect the operators, as well as the City, are very fortunate in having Mr. Carmein as superintendent of the Sutter Packing Company. The following improvements were made at the cannery: Fine screens were installed on all floor drains and provision made for their regular cleaning; A "Cyclone Beater" having a $\frac{1}{16}$ in. screen was acquired and all waste tomatoes were passed through it to remove as much of the fibrous material as possible; A continuous operating, mechanical screen was designed and installed by the Packing Company

through which all the waste water flowed; Finally, provision was made to collect all the screenings removed from the waste water in the above three ways and to truck them to the city garbage dump where they are buried.

As a result of these "preventive measures", the 1935 canning season did not inconvenience or disrupt the operation of the sewage treatment plant. Practically no solid fruit was noticed in the sewage. Peach pulp did collect on the surface of the clarifier but the skimming arm was able to clear the tank in four or five hours. During the 1936 tomato season quite a bit of trouble was experienced with the sewage pumps being clogged with tomato skins. The skins would work their way between the casing and the runner and roll up into tight wads. This trouble did not occur during the 1935-36 tomato season. The probable reason for this trouble is that the clearance between the runner and wearing ring had increased by wear so that the fresh water seal no longer functioned to keep out such material. The pumps soon became overloaded and it was necessary to remove the entire upper half of the pump casing to remove the skins.

In spite of these screens and beaters, some solids still entered the sewer, caused no doubt by operation. During one visit to the cannery during the peach season, the operator noticed that all waste material on the floor was swept into the sewer past the screen by one of the workers. Another waste from the cannery which caused much trouble at the plant was wood from broken packing boxes. The digester operated normally throughout the canning season, and the only visible effects on it were a drop in pH to 7.0 and a marked increase in gas production. The maximum daily amount of gas produced during the peach season was 37,000 cu. ft. as compared to the yearly average of 25,000 cu. ft. Although operation of the plant was not inconvenienced by the cannery wastes, the efficiency of the plant was greatly reduced. In other words, the effluent discharged to the bay was stronger in organic load and suspended matter than the ordinary domestic raw sewage. If this condition is permitted to exist four and one-half months of the year it would seem unnecessary to treat the sewage during the remaining part of the year. Table II. compares the plant effluent produced when the cannery is working with the regular domestic effluent.

1937 Canning Season—What to expect. During the past winter the Sutter Packing Company has remodeled the interior of the cannery, increased its floor space, and has acquired much new machinery and equipment. As a result the cannery is an up to date packing plant with increased capacity of 10%. By comparing with the pack for the past two years, the sewage plant can expect an equivalent increase in canning waste load. Also since the capacity of the packing plant has been increased, one can expect a more concentrated canning waste reaching the sewage plant than heretofore.

What Should Be Done and To What Extent. The problem which faces the Palo Alto Plant is to determine what maximum limit the quality of the effluent should never be allowed to exceed. For this type of plant the effluent may be just as polluted as the raw sewage and the plant will still operate the same. So far, no complaints have been re-

ceived during the canning season since the San Francisco Bay is big enough to take care of the extra load. However, since the sewage plant has been an expensive project, it seems that, if the City is going to get its money's worth out of it, the plant should be made to produce an effluent of consistent quality all year round. Therefore the limit of quality of the effluent should be that average quality which is produced during the eight months of the year when only domestic sewage is received at the plant. In order to bring this about additional treatment would be necessary either at the cannery or at the Sewage plant. Since the scope of this paper does not cover the type and cost for such a treatment, it will not be discussed here.

STRENGTH AND CHARACTER OF CANNERY WASTE

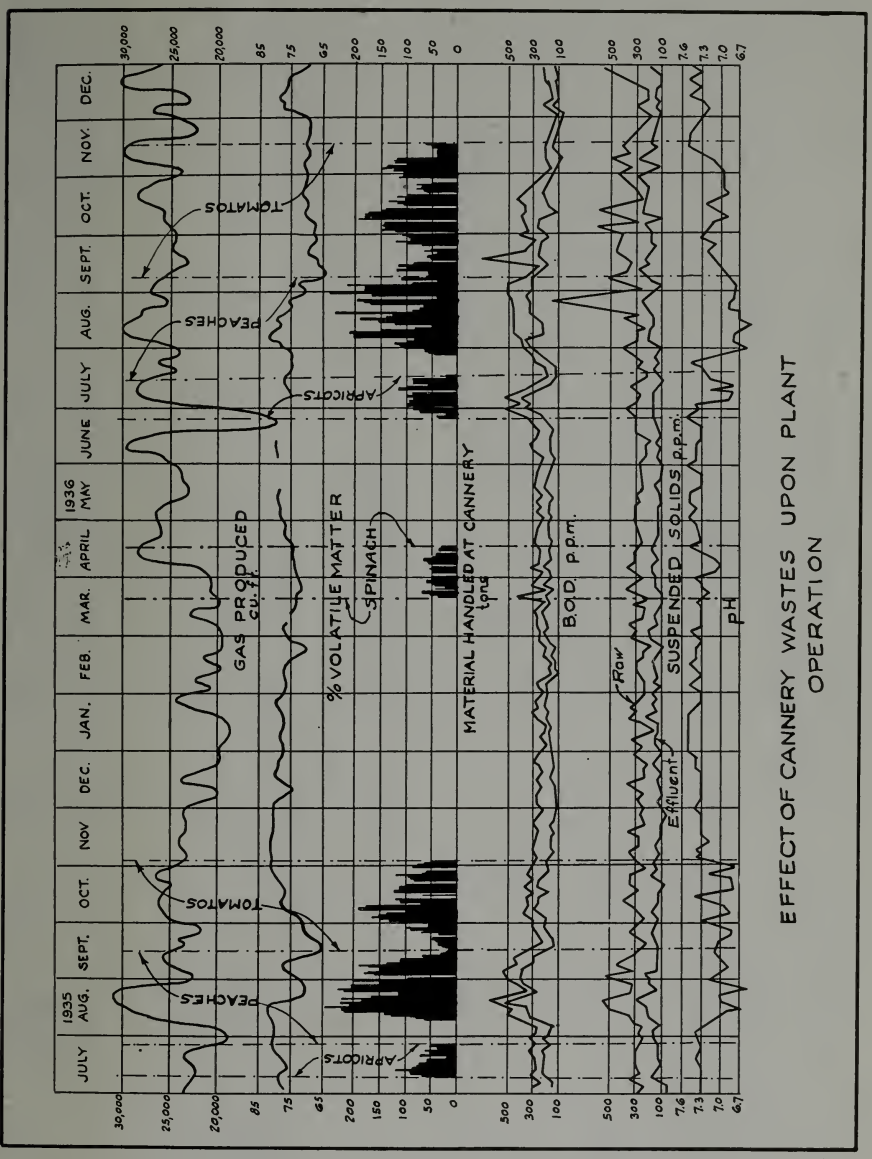
At the beginning of the 1936 spinach canning season in April, a definite schedule was set up for sampling and testing the wastes. This was followed throughout the pack of apricots, peaches and pears, and tomatoes in succession. As a result, some data were obtained, and although quite inconsistent at times, it enabled us to make a rough estimate of the strength of the canning wastes expressed in biochemical oxygen demand. The comparative results are shown in Table I.

Schedule of Tests. When possible a series of tests were run on the same days that similar tests were run on the raw and settled sewage at the plant. These regular test days are Tuesday and Friday, but many times the cannery would not be working so that samples were taken on other days. The schedule included the following laboratory tests: B.O.D., suspended solids, temperature, and pH. As a confirmatory test, oxygen consumed by permanganate was determined as often as possible, on both cannery waste and sewage.

Method of Sampling. Since there is no standard method for sampling of trade wastes, it was important to decide on how to obtain a sample that would be representative of the waste discharged into the sewer for any one day. During the spinach season it was attempted to get a composite sample for a day's pack. With the cooperation of the plant superintendent a worker was instructed to take a sample (300 ml) every hour. The next morning this composite sample was taken to the sewage plant and was tested along with the composite samples of the raw and settled sewage. After several weeks, however, this method of sampling was abandoned since the temperature of the spinach waste, 45° C, was too high to be retained as a composite sample. Also the sampling technique could not be depended upon. For the rest of the season, therefore, catch samples were taken at 11:00 A.M. which according to the superintendent was the time when the cannery was most likely to be running uniformly.

For spinach, a catch sample is probably fairly representative, since the cleaning and wilting process are continuous and no chemicals are used. There are discharges of hot, clear water when the cookers are periodically opened. Samples were taken in between these discharges.

It is more difficult to get a representative sample of apricot waste since apricots are canned either with or without their skins. A lye process removes the skins and, therefore, increases the organic and chemical content of the waste water. The character of the waste when



a catch sample is taken depends upon which one or both of the above methods is in operation.

Peaches go through a more consistent process since it is necessary to remove the fuzz and skin in the lye tank where most of the organic matter and waste water originates.

Pear season is coincident with the Peach season, but no tests were run on this waste as the pears were packed at night.

TABLE I
CHARACTER OF CANNERY WASTES AT PALO ALTO
1936 SEASON

Type of Waste	QUANTITY HANDLED: Total Tons For Season	Mean Tons/day	Maximum Tons/day	Waste Water Gal/ton	No. Samples Tested	Temp. °C	pH	Suspended Solids ppm	Oxygen Cons. ppm	B. O. D. ppm: Max.	B. O. D. ppm: Mean	Population Equiv.: Max. Persons	Population Equiv.: Persons/ton Mean
SPINACH	1173	49	71	8100	4	45	7.3	90		810	730	20,800	290
With Lye Treatment					1				2000	460	380	5,900	49
APRICOTS	1386	77	120	2500									
Without Lye Treatment					1	30	over 7.6	260	700	210	200	3,100	26
PEACHES	4279	97	208	2600	7	31	over 7.6	600	2000	over 1500	1350	37,300	179
PEARS	771	20	41	2580	..	..	...	...					...
TOMATOES	5800	88	196	3600	6	32	6.6	270	1160	1200	990	35,300	180

TABLE II
VARIATION OF PLANT EFFLUENT DUE TO TYPE OF CANNERY WASTE
1936 SEASON

Type of Waste	Mean % Increase in Flow	MEAN VALUES OF B. O. D.: Waste	Raw	Effluent	% Reduced in Raw	% in Excess of Domestic Effluent	MEAN VALUES OF SUSPENDED SOLIDS: Waste	Raw	Effluent	% Reduced in Raw	% in Excess of Domestic Effluent
DOMESTIC	0.0	0	240	165	31	0	0	290	140	52	0.0
SPINACH	21	770	295	190	36	110	90	320	160	50	110
With Lye Treatment		380									
APRICOTS											
Without Lye Treatment	19	200	430	330	23	170	260	250	140	44	0
PEACHES AND PEARS	31	1350 (Peaches only)	420	300	28	180	600 (Peaches only)	450	200	56	140
TOMATOES	18	990	350	220	37	140	270	325	150	54	107

Tomatoes produce a waste which is more dependent on the amount of spoiled and waste fruit than in the variation of the canning process, since all waste tomatoes are put through the "Cyclone Beater" and the liquid wasted to the sewer.

It is realized that this Method of Sampling can not be depended on as truly representative, but will serve the purpose in this preliminary investigation of canning wastes and their effects on the Palo Alto sewage.

LABORATORY PROCEDURE

B. O. D. tests were run following Standard Methods, with one exception. Due to the fact that our plant is not equipped with an incubator, we have used for this a crockery waste jar filled with water at room temperature. Daily B. O. D. tests cannot be run due to the limited amount of equipment and storage space available. Bi-weekly tests so far have proven adequate.

On sewage, the dilution ratio varies between 1.0 and 3.0. We decreased this ratio for cannery samples to the range 0.25-1.00. This is not a range in which to expect much degree of accuracy with 250 ml. sample bottles, but it was necessary to obtain our results as best as we could. To compensate somewhat for this probable error, several samples with other dilution ratios were run as checks. There was a large variation in these results as might be expected especially in the case of peaches and apricots. However, in all cases enough samples were taken over each season so that a good indication of results was obtained, and enabling us to get good indications of mean values.

Oxygen consumed tests were run in accordance with standard methods, using a strong solution of permanganate and digesting for half an hour. Few checks on this method were run from day to day due to the consistency of results.

Suspended solids are run using a Gooch crucible, and using a 50 or 100 ml. sample, depending upon the amount of suspended matter present. Temperature of the sewage was taken at 11:00 A.M.

METHOD OF COMPUTATION

In order to determine the effect of the cannery upon the plant and the laboratory results, it was necessary to find out how much water the cannery discharged into the sewer. An estimate of this daily quantity was obtained by multiplying the number of hours the cannery ran plus two hours for cleaning up by the number of gallons per hour of water pumped. There is no water meter at the cannery since they have their own well.

Population equivalents of the various wastes were calculated using the mean B. O. D. values, the number of gallons of water used, and number of tons of materials handled. Using the value 0.162 lb. of oxygen consumed per capita and substituting in formula: B. O. D. (ppm) x 8.33 x (no. gal. water used/ton) $\div$ 0.162 = no. persons/tons or the population equivalent. Maximum and mean values for each waste were calculated. The population equivalents per maximum number of tons handled per day were also calculated as these would affect future design. The number of pounds of oxygen consumed per capita of raw sewage was figured using the 1936 average flow of 1.66 m.g.d., B. O. D. of 240 p.p.m., and a population of 20,500.

$\frac{240 \times 8.33 \times 1.66}{20{,}500} = 0.162$. This agrees with an average value of 0.167 pounds per capita as obtained by Reinke.[2]

From the values of the mean population equivalents, it is seen that there is a load on the plant from the wastes alone equal to and greater than that furnished by the domestic sewage. However, from Table II. showing the variation of the plant effluent with different types of cannery wastes the B. O. D. and suspended solids tests show that this load is less than twice the strength of average domestic sewage.

According to our results, peaches, pears, and apricots are the strongest of the wastes, followed by tomatoes and spinach. In the case of the first three, the effluent is worse with regard to oxygen demand than ordinary domestic raw sewage. Tomatoes and spinach also produce an effluent which is very poor in quality.

[2]Bulletin 28. California State Division of Water Resources.

SEWAGE DISPOSAL IN THE PACIFIC NORTHWEST

By CARL E. GREEN*

The states of Idaho, Oregon and Washington, situated as they are in the northwestern corner of the United States, have many things in common. Their principal industries are based upon timber, agriculture, fisheries, stock raising and mining. Nevertheless, each is different from the other and within the confines of each state one finds considerable variation in topography and climate. The Cascade mountains divide both Oregon and Washington into two distinct portions—(1) the western, which is well supplied with precipitation except during midsummer and which extremes of temperature are usually lacking, and (2) the eastern, which is arid to semi-arid except in the high mountains where heavy snows fall, and in which low winter and high summer temperatures are common. Idaho's climate resembles that of eastern Oregon and Washington. Along the coast line of Oregon and Washington considerable difference exists. The Puget Sound provides navigable water ways to Washington's two largest cities, Seattle and Tacoma. The Olympic peninsula of Washington probably receives more precipitation than any other area of comparable size in the United States. No large cities are to be found on the Oregon coast line (Portland being 105 mi. up the Columbia River).

Slowly melting snows and glaciers in the Columbia basin together with many mammoth lakes in Washington and Idaho act as flow regulators of the Columbia River and its tributaries. Winter and spring flood flows are not only greatly reduced but fairly uniform summer stream discharges are thus maintained, to the benefit of sewage disposal as well as irrigation, power production and flood control. The Columbia River is exceeded in size in the United States only by the Mississippi River. Off hand it would seem logical to expect that sewage disposal by dilution would be widely practiced in an area such as this

*Oregon State Sanitary Engineer.

having so many large streams and convenient ocean water. Because of the abundance of water and because these three states are relatively sparsely settled, sewage treatment has lagged behind that in some other more populous areas of the country.

In recent years a sewage and industrial waste treatment program has made a significant start. It seems probable that the ultimate result will be the prevention of serious pollution before restoration of streams becomes difficult if not impossible to accomplish.

Idaho had a population of 445,000 in 1930 and an estimated population of 448,000 in 1935. Boise, the state's capital and largest city, has a population of 21,000. Sewers have been constructed in cities and villages which have a combined total population of 173,000. Only two towns have complete treatment plants—Rupert and Meridian. Many of the small towns have old, obsolete septic tanks. The largest cities, Boise, Lewiston, Pocatello, and Twin Falls all discharge raw sewage into the Snake River. Several cities and many irrigation districts use Snake River water, but a fairly high dilution is provided by the Snake River.

The 1,563,000 population of Washington just exceeds the combined population of Oregon and Idaho. Until 1936, only one complete sewage treatment plant was in operation in Washington—at Walla Walla. During the past year several plants have been under construction in the Yakima River valley. The largest plant, at Yakima, is noteworthy in that its flow varies from 4.2 M.G.D. (190 gal. per capita) during December, January, February and March to a maximum of 18 M.G.D. during the irrigation season. High ground water and infiltration account for the high flow. The Yakima plant provides for primary treatment and chlorination during the summer. This plant, as well as others in the Yakima valley, is being constructed principally to reduce pollution of irrigation water which in turn pollutes community and farm wells throughout the irrigated districts. A sanitary survey of the Yakima River by the Washington State health department showed sewage pollutions to be the cause of the high incidence of typhoid fever which has prevailed in the area for many years.

Primary plants have been or are being constructed at Selah, Zillah and Wapato. Colfax has recently let contracts for the construction of a complete trickling filter plant. Plans have been prepared for plants at Lynden, Dayton and Ellensburg. In the western portion of Washington very few sewage treatment plants have been built. Seattle has been working toward the elimination of all sewage from Lake Washington by construction of interceptors and pumping stations to divert sewage to Puget Sound.

Wastes from pulp and paper mills and canneries have given the State of Washington much concern. Paper mill wastes are discharged primarily into salt water but damage to shell-fish growing areas by sulphite waste liquor has been claimed by the shell-fish industry. Canneries are increasing in number and capacity both in Washington and Oregon, and disposal of their seasonal wastes creates a serious problem, especially since cannery operations usually coincide with low stream flows.

Though 62% of Washington's population lives in cities and towns served by sewerage systems, only 10.6% of this population or 6.6% of the state's total population is provided with some kind of sewage treatment.

Oregon, with a population of 1,000,000, has led both Washington and Idaho in sewage treatment, since ten of its cities now have complete treatment plants (1 intermittent sand filter, 3 activated sludge, and 6 trickling filter plants) in operation. In addition, 4 cities have modern, primary treatment plants and construction has just started in another. Nineteen others have septic tanks. Chemawa and Warm Springs Indian Reservations and the Multnomah County farm have adequate, complete treatment plants. In addition, septic tanks are in use at eleven institutions.

The eastern and southwestern portions of Oregon are reasonably well provided with sewage treatment plants, but the Willamette valley is not. Though the Willamette valley contains only 12% of the area of the state, nevertheless it has 71% of the state's urban population. It is in this valley that the next major activity in sewage treatment should take place. When it does, the relatively small proportion of the state's urban population now provided with adequate treatment facilities will be greatly increased.

Portland, as well as being the most important commercial city of the Willamette valley and the state, is also the key city in so far as sewage treatment is concerned. Its problem of sewage treatment is complicated by the fact that the city now discharges combined sewage into the Willamette River through about 55 outfalls on both sides of the stream. A few outfalls empty into Columbia Slough on the north of the city. The most difficult and costly part of the Portland project is that of intercepting sewers, under-river crossings, pumping stations, and a tunnel necessary to collect and convey the sewage to a treatment site near the Columbia River. The estimated cost is $8,240,000. The proposal provides for primary treatment and discharge into the Columbia River rather than complete treatment and discharge into the Willamette River.

Industrial wastes create problems in many sections of Oregon; wastes from pulp and paper mills and canneries are among those most difficult to treat. A start is being made this year in cannery waste treatment. Of the many processes for the treatment and recovery of by-products from waste sulphite liquor, none so far has seemed economically attractive for Pacific Northwest mills. Sulphite liquor wastes discharged into the Willamette River have an equivalent population load on the stream which exceeds the total urban and rural population load of the valley. Wastes from flax retting plants, woolen mills, meat packing plants, tanneries, and many other industries add to the organic load of the Willamette River.

Except in a few instances where water supplies and fisheries are concerned, the economic approach to the problem of stream cleansing in Oregon is subordinate to the esthetic reasons for waste treatment. In this respect a fundamental difference may be noted when comparing stream purification activities with those in most other parts of the

country. Public water supplies are not involved by stream pollution to any great extent and it is unlikely that they will be for a long time to come. Preservation of the fishing and recreational values of the state's streams and lakes as one of the state's most treasured resources is uppermost in the minds of those who have furthered the cause of sewage and waste treatment.

The same general approach to the problem also prevails in Washington and Idaho, but a direct correlation between stream pollution and public health has been demonstrated in some parts of both of these states. In Idaho more public water supplies may be affected by stream pollution than either Oregon or Washington, especially if population and industries should increase greatly in the Snake River valley.

With a few exceptions, stream pollution in the Pacific Northwest has not yet reached a critical point. The Willamette River at Portland during late summer and early fall presents an effective barrier for the passage of salmon up stream, i.e., practically zero dissolved oxygen for about three miles. The Yakima River of Washington is being freed of excessive pollution. The task before the Pacific Northwest states is the elimination of the few critical conditions which exist at present and the prevention of further excessive burdens of pollution on the many streams in the area.

POLLUTION OF THE MOKELUMNE RIVER BY WINERY WASTES

By PAUL A. SHAW*

The wine industry in the Lodi area, San Joaquin County, California, has developed rapidly during the last few years. With this development there has been an increased volume of waste disposal to the Mokelumne River, resulting in a pollution problem of major importance.

An initial survey of winery operations, character of waste products and methods of disposal, was conducted by the State Bureau of Sanitary Engineering during the 1933 season. These data have been summarized and published by DeMartini (1). The same bureau, in cooperation with the San Joaquin Local Health District, carried on a study of river conditions in 1935 and the Division of Fish and Game combined with these agencies for further investigations during the summer and autumn of 1936. Population equivalents established by DeMartini and other data from the several surveys have been utilized in preparing this paper.

WINERY WASTES

Wineries in the Lodi area are principally sweet wine and brandy producers and therefore operate equipment for the distillation of wine. The still slop from the distillation process is the major factor contributing to pollution of the Mokelumne River, thus creating a more acute problem than exists in areas suitable for dry wine, which do not require brandy for fortification.

Waste products from sweet wine manufacture include pomace, lees, wash water and still slops. The pomace is a garbage like material composed of seeds, skins, particles of stems and heavy sediment separated from the new wine after fermentation of the crushed grapes. This

*Division of Fish and Game, State of California.

pomace, totalling about 600 lb. per ton of grapes, is ordinarily disposed of on land and is not a factor in stream pollution.

The new wine, approximating 150-180 gal. per ton of grapes, is subsequently transferred from tank to tank and a thick sediment or sludge known as "lees" is separated. The method of handling lees varies to a considerable extent but in most instances this material is finally discharged to the sewer in combination with other liquid wastes. The principal source of danger from lees is their discharge in batch lots producing a slug of concentrated waste, a condition that has been observed several times in river studies. The volume of lees is 5-7 gal. per ton with a population equivalent approximating 35 persons.

Wash water from floors, tanks and filters produces a medium strength waste of 50-100 gal. per ton having a population equivalent of about 5 persons.

The still slop consists of all wine utilized as still material minus the alcohol content. The volume amounts to 0.9 gal. plus approximately 2 gal. of condensing water for each gallon of still material. The population equivalent per ton of grapes utilized as still material totals 225 persons. Approximately 40% of the total tonnage is required to produce sufficient brandy for sweet wine fortification, but the Lodi area manufactures considerable brandy in excess of that necessary for sweet wines.

Plant operations are subject to wide variation, resulting in a marked fluctuation of waste, both in volume and strength. For this reason it is difficult to determine average or the most critical conditions existing in the river. Grab samples of waste from five wineries, tested by the Bureau of Sanitary Engineering, gave the following average values:

Oxygen consumed	6800 p.p.m.
5 day B.O.D.	3500 p.p.m.
Total solids	8000 p.p.m.
pH	4.0

The value for oxygen consumed represents the true oxygen demand more nearly than the biochemical oxygen demand since winery wastes seem to inhibit normal biochemical activity in the B.O.D. dilutions. In river samples this effect has not been observed and Ingram, of the San Joaquin Local Health District, found that oxygen consumed and biochemical oxygen demands were practically identical on such samples.

In general, the mixed wastes are carbonaceous in character, and form an excellent medium, in river water, for the growth of various types of fungus. The best approximation of total population equivalent now available is 40 per ton of grapes plus 225 per ton of grapes utilized as still material.

PRODUCTION DATA AND POLLUTION LOAD

For the past two years, five wineries have discharged waste containing still slops to the Mokelumne River. These wineries handled 110,571 tons of grapes during the 90 day season of 1935 and 46,264 tons in the 60 day season of 1936. While the tonnage in the latter season was only 42% of that in 1935, the records indicate 52% with respect to still material. Due to a shorter season, the pollution load was reduced to a

lesser extent and is calculated at 73% of the 1935 load for the period of operation.

The average population equivalent for 1935 is calculated to be 224,000 with a maximum of 384,000 at the peak of operations, while in the following season the average population contributory to the river is calculated to be 163,000. An estimate of peak load for the 1936 season does not appear warranted since operations were more or less intermittent and it is questionable whether the river received capacity still wastes from all five plants at any time.

The flow of wastes to the river was estimated to average 450,000 g.p.d. in 1935 and 340,000 g.p.d. in 1936 with a maximum flow approaching 800,000 g.p.d. in 1935.

The pollution load contributed by the above wineries does not represent all of the potential load that could be discharged to the river, as there were three additional wineries in 1935 and six in the following year that were suitably located to use the Mokelumne River for disposal if permitted. The records on tonnage, still material and still capacities, for this group, indicate that the pollution load would have been increased 24 to 37% in 1935 and 62 to 72% in 1936, if this additional burden had been sewered to the river.

AVAILABLE DILUTION

Water flow in the Mokelumne River is controlled at the Pardee Dam from which Oakland and other East Bay cities obtain their water supply. A smaller dam located at Woodbridge, a short distance below Lodi, serves to divert water for irrigation purposes. Four of the contributing wineries are situated in the area 3 to 6 mi. above Woodbridge and the fifth a half mi. below this point.

During the height of the season in November, 1935, the average flow was 560 sec. ft., with no diversion to the irrigation canal, providing a dilution of 2.5 sec. ft. per thousand for the average load of 224,000 population and a dilution of only 1.46 sec. ft. for the maximum load of 384,000. The flow in October was even less, averaging 515 sec. ft. above the dam and 432 sec. ft. below. In 1936, the operating peak was in October, the average river flow being 525 sec. ft. above the dam and 400 sec. ft. below, providing an average dilution of 3.2 sec. ft. per thousand for the load of 224,000, 96% of which was discharged above the dam. Based on the formula given in the last edition of Standard Methods of Water Analysis, the above dilutions would result in 5 day oxygen demands in the river as follows:

Average 1935	12 p.p.m.
Maximum 1935	20.5 p.p.m.
Average 1936	9.3 p.p.m.

PHYSICAL DATA

Since river characteristics such as velocity, surface area, depth and elapsed time of flow have a marked bearing on the final effect resulting from organic pollution, a brief description of these factors appears desirable. For this purpose the Mokelumne River may be divided into four sections.

Section I. extends from the first source of pollution to the Woodbridge Dam, a stream distance of 5.9 mi. While there are considerable

areas of overflowed land in the lower half of this section, float tests indicate that the main flow of water follows the channel, the capacity of which is governed largely by elevation of the gates at the dam and is affected only slightly by changes in volume of flow.

Section II. from the Woodbridge Dam to the Galt Bridge, a distance of 14.8 mi., is a meandering stream with well defined banks and fairly constant cross section. There are no large diversions of water or additional dilution from tributaries in this section.

Section III. covering a stream distance of 7.2 mi., from the Galt Bridge to New Hope Landing is affected by tidal action, the upper limit being somewhat above the Galt Bridge. The direction of flow reverses with the tide, moving the body of water up and down stream without additional dilution. The channel is wider and deeper.

Section IV. downstream from New Hope Landing, is still wider and much deeper, there being several side sloughs and channels before reaching Terminous, a distance of 10 mi. In the first 5.4 mi. of this section on which capacity data were obtained, tidal action moves the body of water a greater distance than one day's flow, but without effecting any significant dilution with fresh water from the lower river.

Data on the four sections for conditions in October, 1936, calculated from float tests and from records of the U. S. Geological Survey and U. S. Coast and Geodetic Survey are given below.

	Section				
	I	II	III	IV	Total
Length-miles	5.9	14.8	7.2	4.5	33.3
Average depth-feet	8.	5.6	9.6	17.7	
Surface area-acres	82.	180.	94.	136.	492.
Average downstream velocity-ft./sec.	.6	.75	.4	.11	
Elapsed time of flow-hours	15.	29.	27.	72.	144.

The physical data indicate that critical conditions of oxygen depletion are more likely to occur above the Woodbridge Dam and in the tidal area below the Galt Bridge than would be anticipated in Section II. This fact is based principally on greater depth, resulting in proportionately higher demands per acre of available reaeration surface and less aeration with decreased velocity.

CHEMICAL DATA

Determinations of dissolved oxygen, oxygen consumed, pH, and other sanitary and chemical analyses were conducted on samples from a series of river stations in 1935 and 1936. The three analyses first mentioned are the only ones reported here since significant changes were not observed in other components. As previously noted, 5 day biochemical oxygen demands on river samples were similar to oxygen consumed values so that only the latter are reported.

In 1935, the analyses were on samples collected during the period of winery operations at stations down to the Galt Bridge. In 1936, one survey was conducted on August 18, prior to the winery season, and a second on October 28, the testing stations extending from above the first source of pollution to New Hope Landing, a distance of 28 mi. On October 22, a survey, via boat, was made from the Galt Bridge to

Terminous, and supplementary analyses were made at a number of stations during September and October. Table I. covers the minimum oxygen and pH values and the maximum oxygen consumed values observed at the different stations. Table II. indicates all determinations for the survey by boat on October 22.

From Table I., it will be noted that the minimum dissolved oxygen in August varied between 87 and 96% saturation and that during the winery season the minimum noted above the first source of pollution was 92%. During the period of waste discharge, oxygen values fell rapidly from the first source of pollution to the Woodbridge Dam where a minimum of 60% was observed. The dam serves as a valuable source of reaeration and the minimum noted immediately below this point was 88%. Comparative tests indicated that the dam furnished a 60% recovery of any existing oxygen deficiency. Below this point oxygen values again decreased with a minimum observed value of 46% at New Hope Landing.

Maximum observed values for oxygen consumed rose from 2.6 before winery operations to 14.5 during the '36 season and to 16.4 for the '35 season. Minimum pH values dropped from 6.8 before the '36 season to a low of 6.5 in 1936 and 6.0 in 1935.

From Table II. covering the tidal area survey by boat, it will be noted that oxygen values ranged from 52 to 64% for a distance of 9½ mi., the lowest values being in the area below New Hope Landing. Since a value of 46% had been previously noted at New Hope Landing, it is doubtful whether the above values represented the most critical conditions of the season below that point. Unfortunately it was not possible to obtain the patrol boat for a second survey of this section and in the event of future studies it would be desirable to make more detailed tests in that area. It will also be noted from Table II. that oxygen recovery was evident 8 mi. below New Hope Landing and 30 to 36 mi. below the major sources of pollution, the elapsed time of flow being 7 to 8 days.

The chemical analyses indicate a normal, unpolluted stream prior to the winery season and show that the addition of winery wastes created two areas of partial oxygen depletion. These areas lie in the section immediately above the Woodbridge Dam and in the tidal section already discussed, substantiating calculations from the physical data which indicate that the average pollution load of 163,000 will result in oxygen demands on the river distributed as follows:

River Area	Oxygen Demand lb./acre/day
Above Woodbridge Dam	61
Woodbridge to Galt	40
Galt to New Hope Landing	53
New Hope Landing to —5.4 mi	57

A value of 120 lb./acre/day is generally accepted as the maximum oxygen reabsorption at zero saturation. Streeter, in recent publications, has shown that aeration is directly proportional to the degree of oxygen deficiency (providing other factors remain constant) and this fact has been confirmed in experiments by Shaw (2). On this basis

TABLE I. MOKELUMNE RIVER SURVEY, 1935-1936

Station	Stream Distance Miles	Minimum D.O. % Sat. Aug. 1936	Minimum D.O. % Sat. Sep.Oct. 1936	Minimum D.O. % Sat. Oct.Nov. 1935	Maximum O.C. Aug. 1936	Maximum O.C. Sep.Oct. 1936	Maximum O.C. Oct.Nov. 1935	Minimum pH Aug. 1936	Minimum pH Sep.Oct. 1936	Minimum pH Oct.Nov. 1935
Above pollution	.0	96	92	95	1.5	3.8	3.1	7.1	6.8	6.5
C.C.T.C. Bridge	.4	..	..	95	..	..	16.4	..	..	6.4
Cherokee Bridge	1.7	91	84	89	1.6	8.8	13.7	7.1	6.6	6.0
Buck Beckman Line	3.7	96	72	85	1.8	7.9	14.5	7.2	6.6	6.5
Woodbridge Dam	5.9	87	60	64	1.9	10.1	13.7	6.9	6.6	6.5
Below Woodbridge Dam	6.0	95	88	78	2.1	..	13.0	7.1	..	6 5
2.4 mi. bel. W.D.	8.4	..	80	..	..	10.9	..	..	6.8	..
Acampo Road	9.1	..	79	..	..	10.6	..	..	6.6	..
Davis Road	12.0	96	77	70	2.3	14.5	14.2	7.1	6.5	6.5
Galt Bridge	20.7	90	76	64	2.6	6.6	14.4	7.0	6.7	6.0
Benson Ferry	23.	87	61	..	2.3	9.0	..	7.0	6.7	..
New Hope Landing	27.9	89	46	..	2.3	5.5	..	7.0	6.7	..

TABLE II. MOKELUMNE RIVER SURVEY, 1936

Station	Time	Temp	D.O. % Sat.	O.C.	pH
1 Mile above Galt Bridge	11:16AM	16.5	80	..	6.9
½ Mile above Galt Bridge	11:10AM	16.5	80	4.4	6.9
Galt Bridge	11:03AM	16.5	81	..	6.9
5.0 Mi. above New Hope Landing	10.58AM	17.	81	4.1	6.9
4.5 Mi. above New Hope Landing	10:50AM	17.	81	..	6.9
4.0 Mi. above New Hope Landing	10:43AM	17.	78	3.7	6.8
3.5 Mi. above New Hope Landing (Benson Ferry)	10.38AM	17.	61	..	6.7
3.0 Mi. above New Hope Landing	10.32AM	17.	61	5.5	6.7
2.5 Mi. above New Hope Landing	10:27AM	17.	61	..	6.8
2.0 Mi. above New Hope Landing	10.21AM	17.	60	6.1	6.7
1.5 Mi. above New Hope Landing	10:15AM	17.	61	..	6 8
1.0 Mi. above New Hope Landing	10:10AM	17.	64	4.7	6 7
0.5 Mi. above New Hope Landing	10:04AM	16.5	61	..	6.8
New Hope Landing	10:00AM	16.5	62	4.4	6.8
New Hope Landing	1:10PM	17.5	60	4.9	6.7
¾ Mi. below New Hope Landing	1:17PM	17.5	52	..	6 7
1½ Mi. below New Hope Landing	1:23PM	17.5	52	4.0	6.7
2¼ Mi. below New Hope Landing	1:28PM	17.5	60	..	6.8
3 Mi. below New Hope Landing	1:36PM	19.	62	2.8	6.7
4 Mi. below New Hope Landing	1:40PM	19.	56	..	6 7
6 Mi. below New Hope Landing	1:48PM	19.	57	2.7	6.7
8 Mi. below New Hope Landing	1:55PM	19.	75	2.8	7.1
9 Mi. below New Hope Landing	2:05PM	19.5	84	..	..

the demand of 57 lb./acre/day for the three day period of flow below New Hope Landing could not be satisfied at saturations above 52%, at which point an equilibrium between demand and reabsorption would be established. This value corresponds closely with actual observations of 46 to 60% in that area.

Oxygen depletions in the lower river were not determined in 1935, but an average value of 13.6 p.p.m. oxygen consumed was observed at the Galt Bridge and the physical and chemical data of '36 furnishes a reliable means of estimating conditions below New Hope Landing in 1935; comparative calculations indicating that oxygen saturations of 24% or lower probably extended over a considerable area during that season.

AERATION FACTOR

The middle section from the Woodbridge Dam to the Galt Bridge serves as an excellent stretch of river for computation of an aeration factor. The channel is reasonably uniform, without diversions or dilution and the initial oxygen saturation below the dam is fairly constant. Oxygen demand values obtained at the Galt Bridge may be utilized to calculate the oxygen demand satisfied during the estimated time flow interval of 29 hr. from Woodbridge Dam. In this section, the oxygen curve approximates a straight line so that for practical purposes, the average deficiency may be taken as half the sum of the initial and final deficiency.

For a five day demand of 5.6 p.p.m. an average depletion of 1.95 p.p.m. was noted at the Galt Bridge. The demand satisfied in the preceding interval of 29 hr. at the normal rate of biochemical oxidation for the existing temperature would be 2.3 p.p.m. The initial deficiency below the Woodbridge Dam was 0.95 p.p.m. The initial deficiency plus the demand minus the final deficiency indicates an aeration of 1.30 p.p.m. at an average deficiency of 1.45 p.p.m. which is equivalent to 8.77 p.p.m. aeration at zero saturation. Correcting this value to a 24 hr. period we have 7.26 p.p.m. or 19.6 lb./acre foot or 110 lbs. per acre of surface. The above calculations may be combined and expressed by the following formula:

$$A = \frac{130\ S\ W\ (I+D-F)}{T\ (I+F)} \text{ where}$$

A equals Aeration factor at zero saturation in lbs./acre/day
W " Water depth in feet
T " Time interval in hours between stations
S " PPM oxygen at 100% saturation
I " PPM oxygen deficiency—initial
F " PPM oxygen deficiency—final
D " PPM oxygen demand satisfied between stations

Applying this to the conditions observed we have:

$$A = \frac{130 \times 9.8 \times 5.6\ (.95+2.3-1.95)}{29\ (.95+1.95)} = 110\#$$

This formula may be restated to estimate downstream depletions if an aeration factor has been established:

$$F = \frac{130\ S\ W\ (I+D) - A\ T\ I}{130\ S\ W + A\ T}$$

It is anticipated that further work will be conducted on reaeration in the Mokelumne River and other streams and these data will be discussed in more detail in a later publication.

FUNGUS GROWTH AND RIVER APPEARANCE

DeMartini noted the appearance of Sphaerotilus like fungus growths in the river with winery waste dilutions of 1/1300. Similar growths have been noted in greater abundance during subsequent surveys. The river also develops a typical dark appearance with a mirror like cast during the winery season.

EFFECT ON FISH LIFE

Until recent years, the Mokelumne River has been noted as a fishing stream, black bass and salmon being the important species. During the past few winery seasons, dead fish have been observed by numerous people and the runs of migratory salmon have shown an alarming decrease. In the peak production year of 1935, practically no salmon came upstream which indicates that a barrier may have been established in the lower river. This section is quite isolated and fish fatalities might not be reported, the principal reports of such losses coming from the vicinity of Woodbridge Dam.

In the 1936 season, a series of fish tests were conducted by placing bluegills, black bass and other species in cages submerged in the river at points above and below pollution. All the fish died in tests just above the Woodbridge Dam and heavy losses occurred near the upper end of the lake. The losses appeared to occur during short intervals of increased pollution load and are believed to have resulted from suffocation. Tests near discharge outlets seemed to indicate that oxygen depletion is the controlling factor rather than direct toxicity. No cage tests were made in the lower tidal area.

The fungus growth is irritating to the gills of fish and heavy deposits of fungus and sediment have frequently been observed on the gills. It is also probable that a high oxygen demand would result if the fungus is killed by sudden temperature changes, a condition that was observed during studies of pollution in the Eel River from dairy wastes. The possibility that winery wastes have a deleterious effect on aquatic organisms and fish foods should also be investigated. Along this line, it would seem that the observations of local people familiar with river and fishing conditions are extremely valuable. After all, we have a tendency to estimate the degree of pollution on a few simple tests, when in reality there may be many other factors deleterious to aquatic life of which we know little at the present time, the resulting effect of which may be noted by local observers.

RESTRICTION OF WINERY WASTES

As a result of the findings to date an order has been issued by the Division of Fish and Game prohibiting further discharge of still slops

and other concentrated wastes to the river. Further studies will be conducted to determine whether additional restrictions will be required. Since the issuing of this order, the California Wine Institute has launched a program to assist their member wineries in solving the problem of satisfactory waste disposal. Whether this will prove to be evaporation, chemical treatment, filtration, land disposal or some other method has yet to be worked out.

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PUMPS, BEARINGS, CLARIFIERS AND PLANT LAYOUT

By CARL F. TENNANT*

Criticism has been solicited from operators. Therefore, I propose to treat the subject of mechanical equipment and plant design candidly and without reserve. The shortcomings of sewage plant design and mechanical equipment will here be presented from the operator's viewpoint in the hope that through a mutual comprehension of the problems that harass the operator, better equipment and improved design will result. If this is accomplished in some small way, this effort will be well repaid.

SLUDGE PUMPS

Let us first consider sludge pumps. Raw sludge is difficult material to handle with any pump. If the characteristics of sludge are considered it is apparent that some of the equipment for pumping sludge now on the market is obviously unsuitable for this purpose. Sludge is fibrous material containing small sticks, bones, sand, seeds, rags and finer particles mixed with varying amounts of water. It should therefore be apparent that almost any valve arrangement in a sludge pump will soon foul and give much trouble.

Some piston pumps widely used in sludge pumping have large rubber ball valves in the suction and discharge and it is obvious that they cannot operate very long without catching a stick, seed or some other object that will prevent proper seating. The pump, then, simply breathes back and forth through the opening until cleaned by the operator. This means taking off the caps and prospecting by hand in the filthy mess to find the offending object. In a short time sand and other abrasive materials in the sludge wear the balls down and some day when the sludge is heavy and the friction high in the discharge line the suction valves will be pushed through the seats and down the pipe. The cure for this situation is not pleasant.

But that is not all that happens to a piston sludge pump. The cylinders are packed around the piston to prevent leakage; the pistons working up and down through this packing carry some abrasive material into the packing where it lodges and continues to grind away at the piston,

*Chief Operator, Joint Disposal Plant, Los Angeles County Sanitation Districts.

which in a comparatively short time becomes hollow in the center of the stroke. When this condition develops it is impossible to pack the pump successfully and at each stroke sludge will hit the ceiling. The trouble might be remedied by covering the motor, enlarging the drain from the building and letting it spurt, or removing the pistons and having them straightened on a lathe. The pistons will stand about two cuts on a lathe, after which sleeves or new pistons must be installed. Pistons of harder material could be made but this would not eliminate the valve trouble. Whenever equipment of this kind is installed it is my guess that it will eventually provoke the curse of some operator.

Diaphragm pumps are not above reproach. They have the same valve trouble plus the temperamental and easily broken rubber diaphragms.

Centrifugal pumps of the two-port end-suction type give fair service but are by no means perfect. The impellers wear altogether too fast in sludge that contains only small amounts of sand and the seal rings between volute and impeller soon become loose enough to pack with matches, hair and rags, which act as a brake upon the impeller. Centrifugal pumps for sludge work should be equipped with hard, tough impellers and seal rings and be designed, as far as possible, to prevent clogging of the annular ring between impeller and volute. Unless otherwise specified they will probably be equipped with bronze shaft sleeves, the bronze being cheaper. Shaft sleeves in centrifugal sludge pumps should be of the hardest material because of abrasive substances in the sludge that lodge in the packing around the shaft. Of course, a centrifugal pump must be of suitable size, not less than 4 inches. A 6-inch pump will give less trouble from clogging. Variable speed is essential.

There is a newcomer in the sludge pump field which combines a screw feed with centrifugal features. The screw is intended to cut up the coarse material and pass it on to the centrifugal impeller. Now, since primary sludge contains a large proportion of abrasive material it seems apparent that any cutting device will not long retain its cutting edge and when the cutting edge is destroyed, the screw feature simply becomes an obstruction in the suction, around which rags may wind.

All centrifugal sludge pumps should be set lower in elevation than the source of supply. A suction lift applied to sludge, and more especially digested sludge, is fatal, because all sludge is charged with gas and when partial vacuum forms in suction the sludge effervesces, releasing enough gas to cause the pump to operate poorly or killing the pumping action entirely. Setting the sludge pumps low facilitates the priming and makes unnecessary the installation of priming equipment which requires maintenance.

SEWAGE PUMPS

End suction pumps, both vertical and horizontal, with two-port, inclosed trash impellers, have been widely used for pumping sewage for many years. Though they are well established, they must come in for their rap. Vertical pumps have the disadvantage of a longer shaft, which requires more bearings. Vertical shafts give rise to lubrication troubles. If sleeve bearings are used and lubricated with oil, the oil does

not reach the bottom bearings for several minutes after the unit has been started but continues to flow down the oil pipes for several minutes after the unit has been stopped. The excess oil plus the oil from the bearings farther up the shaft usually finds its way onto the pump room floor. If cup grease is used the operator is required to do an extensive amount of climbing to screw down cups. If ball bearings are used, the trouble accompanying these bearings is incurred. About the only advantage to a vertical pump is when a pump must be installed directly in a wet well. If a dry well is provided and space is not out of the question, there is little defense for the installation of a wet well pump.

The close-coupled horizontal pump and motor, equipped with split sleeve babbit bearings, using oil for lubrication, is, without doubt, the most dependable, trouble-free unit. Sewage pumps should be set as low as possible to facilitate priming. Sewage, of course, will take a suction lift and the problems of sludge pumping do not apply.

All end-suction pumps, either vertical or horizontal, have the disadvantage of end thrust. This makes necessary the installation of a thrust bearing.

As in the case of sludge pumps, there is a newcomer in this field. This pump, a comparatively recent development, is of the double suction type. Four ports are provided, two drawing from one side and two from the other. This should exert an equalized suction pull upon the impeller and cause it to float between the opposing forces, thereby making any thrust bearing unnecessary. This is ideal, since in a horizontal position, with the shaft running straight through the impeller, both bearings can be split-sleeve babbit with oil-ring lubrication. The shaft, by passing straight through the impeller, does away with all overhang and holds the impeller more rigidly in position thus preventing it from whipping. This pump is deemed suitable only in large sizes and probably could not be applied to sludge pumps of small sizes. Rags might possibly wrap around the shaft in smaller sizes, but in large sizes it is fair to assume that this would not occur.

BEARINGS

Sewage treatment is a perpetual proposition and, therefore, dependable equipment must be provided. No mechanical unit will ever be entirely trouble free and for that reason the equipment installed should be scrutinized with the thought of quickly effecting permanent repairs. Bearings are one source of trouble and therefore the most dependable type should be used in sewage equipment. This, in my opinion, is the split-sleeve babbit bearing that can be easily taken up if slack occurs. It is easy to line and easy to fit. There is little that can go wrong with this old standard. The worst that can happen to it is that it might overheat to the melting point of the babbit. Should this occur—though good operation should not permit it—the bearing can be repoured in a short time and with the aid of a little Prussian blue and a scraping iror it can be fitted and be back in service in a few hours.

The repair of ball, barrel and roller bearings, grouped under the heading of frictionless bearings, is quite another story. When a ball splits or the race becomes worn or chipped, causing the bearing to be noisy or to heat, there is nothing to do except replace it. Since these

bearings come off over the end of the shaft this means taking the machine down with more expense and longer delay.

Full circle or solid sleeve babbit bearings are criticized for the same reason as frictionless bearings; they have no take-up and must be removed via the end of the shaft.

There are, of course, many places where ball bearings are essential and it is not intended to damn them utterly. In sewage equipment, weight, beauty and size are of little importance when compared with dependability, ease of operation and accessibility for quick repairs.

SUBMERGED EQUIPMENT

Now for a discussion of plant equipment that is submerged or inaccessible. There will, of necessity, always be some mechanical units in sewage treatment partially submerged in sewage or sludge, but unless the particular function is essential and can be accomplished in no other reasonable manner, submerged equipment should be avoided. Take for example sludge stirring mechanisms in digesters. If anything goes wrong below the sludge level, it means putting the tank out of service to reach the unit and begin repair. The natural overturning of sludge in digestion seems to provide all the mixing necessary and the value of additional mechanical mixing is questionable. After thorough investigation and trial, mixing in the digesters of the Los Angeles County Sanitation Districts' plant was discontinued. Two years have since elapsed without indicating any difference in results. It seems that this type of submerged equipment might be eliminated. It has been held that the rotating plows concentrate the sludge; if so, about the best they can accomplish is a saving of a day or so in time on the sludge beds, because digested sludge will drop all of its drainable water in 48 hours; the remainder must be evaporated. The reward seems scarcely worth the means.

In the class of submerged equipment the various types of sludge collecting machinery must be scrutinized. Necessarily the sludge collecting equipment will be partly submerged, but, other things being equal, those types are to be preferred which have the fewest submerged parts requiring maintenance. The accepted types of clarifier mechanisms, either center or rim drive, are satisfactory from this viewpoint. They are dependable because they have few working parts and all driving mechanism is easily accessible. Another sludge collector with all moving parts accessible is the traveling bridge. This type is adapted for use in rectangular tanks. The bridge type lends itself to the application of mechanical skimming.

In contrast to these, the chain-flight types of sludge collectors have more mechanism under water where the operator cannot see the equipment. Often the first sign of trouble in this type is when a slat floats to the surface indicating that the chain has jumped a sprocket. Rags wrap around the shaft cause no small amount of trouble. There is no way to get at this submerged equipment other than to dewater the tanks. The wooden flights, dragging on concrete floors, wear badly even when iron shod, and must be replaced from time to time. The blades of the standard clarifiers will outwear them ten to one.

Maintenance of submerged equipment is dirty work. It is not that operators shy at a day's work or the performing of some dirty job. At best there will always be numerous disagreeable jobs to be done in connection with sewage treatment. The operators do object to plant design which makes necessary dirty work which could be avoided. Whether it is admitted or not there is a definite health hazard connected with the treatment of sewage and the less the sewage is contacted by the operators, the lower that hazard will be.

OBSERVATIONS

It is common knowledge that digestion tanks have a tendency to foam and they are almost certain to do so sometime during their life. But I have yet to see any means provided in the plant design to care for this phenomenon, such as special outlets leading to a confined area provided for the purpose of catching the overflow. Instead the tanks foam all over the plant site and the operator must handle the situation with some temporary expedient.

Many sludge lines are laid with no cleaning outlets or with outlets in the wrong location. Pipes are laid through soft backfill that will settle, disjointing the pipe or throwing it out of line, causing gas pockets to form which will give pump priming trouble. Pipes of all description are cast in concrete walls. If the backfill outside the building settles and breaks the pipe at the wall, which it usually does, there is no way to make repair except to chip out the pipe. If the wall is thick and the concrete of good quality it may take a couple of days to accomplish this. Pipes should never be cast rigidly in a concrete wall. Daytons, Dressers or straight sleeves should be provided so the pipe can be withdrawn if necessary. All valves should be rising stem, quick opening, either hydraulic, pneumatic or lever-operated.

Exposed pipes that are subjected to variable temperatures have a tendency to crawl, and in leaded work cut nipples that have no leading bead will crawl apart and finally disconnect themselves. They must be held in place.

'Pump room floors often have insufficient drainage or none at all, with small, undersized sumps to care for the floor washing. A great deal of thought should be given the features that make possible the maintenance of cleanly conditions about the plant. Ample pumping capacity should be provided for use from the pump room floor to care for any serious leak that may occur from unforeseen emergencies.

We sometimes see ladders instead of stairs. If ladders must be installed they should never be of the manhole step variety, with no side rails to prevent greasy boots from slipping off. Much productive thought can be given to safety features.

From time to time phenomenal storms will occur which tax the plant beyond its capacity. At such times, though rare, the facilities to care for these contingencies may relieve the operator of long hours of unnecessary labor, competing with high water. If no provision has been

made to care for these unusual occasions and the operator loses the fight, the plant may be submerged. Should the plant be submerged, are the most important mechanical units vulnerable? When high water occurs the scouring of the lines yields an increase in bar screenings, therefore mechanical bar screen cleaners should be capable of increased speed to prevent clogging upon such occasions.

Some pump houses are cramped beyond reason. It would appear that the equipment had been installed and the concrete building poured around it. Removal or repair of the equipment under such circumstances is difficult. On the other hand, we see some plants all spread out, requiring an unnecessary amount of traveling from unit to unit. This extra distance requires time and energy and reduces efficiency. Another common fault with design is that there is too much up-and-down provided. Running up a flight of stairs every few minutes lessens the amount of useful work an operator can perform. Designers seem to have a fixation that steps are necessary, or: "What are a few steps if you don't have to climb them yourself?"

Now, it is conceded that few men charged with the design of sewage treatment plants have had the benefit of operating experience; they, therefore, do not think in terms of operation. Those who do not possess this dual training would do well to consult with operators of long experience. The amalgamation of the experience of the operator with the training of the engineer will go a long way toward producing a smoother treatment plant. It so happens that a great many of the things that make for smooth, trouble-free operation do not add to the plant cost. Largely they are the product of sufficient forethought, coupled with a thorough experience in operation.

The designing engineer assumes a heavy responsibility in the planning of a sewage treatment plant. Once the plans are made and the plant built, the die is cast and the operator can do very little about it. His province is to maintain that which has been provided. There is a long list of indictments which the operators bring against the engineers. The California Sewage Works Association, through its caravans, has caused a parade of these errors to pass in review in bold relief. The disheartening part of it all, from the operator's standpoint, is that we see the same mistakes made again and again. Why is unsuitable mechanical equipment installed? As a matter of fact, equipment is usually purchased through competitive bidding and if the specifications are not rigidly drawn to insure exactly the type of equipment desired, the important small details will be neglected. It is not entirely unheard of to find some mechanical ignorance displayed by the engineer regarding the correct type of equipment to purchase. A product cheaper in cost and which may appear acceptable to the engineer may be offered and taken.

As Mr. Kennedy stated last year at Santa Monica, the engineer is at times handed the cloth and told to cut the best suit he can from it. That the engineer succeeds in so doing is evidenced by many fine plants throughout the state.

SCREENS AND ROLL PRESSES

By J. H. VAN NORMAN*

All the sewage of the city of Los Angeles, except that of San Pedro, is disposed of at the Hyperion Screening Plant. Dorrco fine screens are used for this purpose. There are ten (10) units in use at this time. Five units were installed in 1925 and five more units were added in 1930. All screens are 14 ft. in diameter by 12 ft. in length. Other mechanical equipment includes de-watering elevators, mechanical rakes on coarse bar screens, air compressors, incinerator equipment, including roll press for de-watering screenings, oil pumps, electric recording pyrometer, air operated sluice gates, air operated effluent gates, electrically operated butterfly gate in main outfall line to ocean and numerous electric motors of various types and sizes. Considerable trouble was encountered with the shaft bearings on the five screens first installed. These bearings were of the roller type. Bronze sleeve bearings were designed and installed and have proven satisfactory. As the space for the roller bearings was limited, 8 in. diameter by 8 in. long sleeve bearings were as large as could be used to replace roller bearings. In designing the five units installed in 1930, sleeve bearings, 10 in. diameter by 10 in. long were used. An important improvement was made when the five units were installed in 1930. This was the use of the automatic log clutch between the driving motor and the reduction gears. This clutch permits the electric motor to attain full speed, then starts to pick up the load gradually without shock to motor or gears. Perforated screen plates have given very little trouble and replacements have been few. These failures were caused by boards or chunks of concrete falling into screen pits and breaking plates. One main shaft had to be replaced and this, of course, called for much time and labor to remove and replace all bolts, plates, spiders, bearings, and other parts. The mechanical rakes now in use are operating satisfactorily. Several changes have been made since the first installation. The entire driving unit, including the motor, is enclosed in a waterproof housing and the gears and drive chain run in oil. The arms and rake blades run in the sewage and must be replaced from time to time as painting does not protect them.

The ¼ in. steel plating on the elevator housings last about five to six years and must be replaced. No. 830 Rexley bushed chain is used for the bucket elevators and it lasts about 18 to 24 months. Brass reinforced elevator buckets suffer mostly from excess sand during the winter months and replacements and repairs are necessary.

Compressed air for ejecting screenings and for various other uses is furnished by an Ingersoll-Rand two-stage type X R B compressor of about 600 cu. ft. capacity. By the use of a low carbon content oil and cleaning the valves when necessary, this machine operates 20 or more hours per day and requires very little attention.

The Morse-Boulger destructor is equipped with Louisville press for de-watering screenings before incineration. The perforated endless steel belt that carries the screenings through the rolls is a weak

*Operator, Hyperion Plant, Los Angeles, California.

part of the incinerator plant. Fruit pits, golf balls, bones and other solid objects that find their way into the sewer, punch holes in the belt and break down the hinges. Sand on the screenings reaches the bearing of the press and it has been necessary to replace roller shafts and re-babbit bearings several times.

Variable speed, wound-rotor slipring induction motors were used on the five screens first installed. These were unsatisfactory because the gases attacked the copper rings, causing excess brush wear and poor contact. Constant speed induction motors are now used and are satisfactory.

Main bearings on the screens and bearings on the elevator drive shafts are lubricated with chassis grease or high pressure grease. A one-shot lubrication system was installed in 1930 serving five screen units; it has proven quite satisfactory.

Cleaning screens is an important duty at Hyperion and part of the ten screens are cleaned every day, except Sunday. Steam is used at about 100 lb. pressure. We also have a "gang roller" designed by one of the operators that cleans out the slots in the screen plates. It consists of several blades of steel so designed as to clean several rows of slots at a time and is pushed along like rolling a wheel.

The mechanical maintenance of a screening plant requires the efforts of trained men. The severe conditions under which the machines and equipment operate, being attacked by the gases and needing replacement and repairs regularly and the electrical wiring, fuses, switches and motors must be taken care of, as any exposed copper will not last long around a sewage plant. In the use of oils and greases I find the best none too good. A poor grade of grease used in a one-shot lubrication system will separate and the soap stock in the grease will plug up the line.

In a plant the size of the Hyperion disposal plant, I believe the best results can be obtained if you have included in the personnel, in addition to the plant operators, a good machinist and an electrician.

FERRIC CHLORIDE FEEDERS AND COMMINUTORS

By ALFRED W. WYMAN*

Two of three pieces of equipment installed at the Pasadena Plant this year may be of interest.

In the preparation or conditioning of sludge for filtering, chemicals in dry or liquid form are used. To control the addition of chemicals, it is necessary to provide some accurate means of proportioning the amount of chemical to the weight of sludge filtered.

For some years batch dosing was employed at Pasadena and was never satisfactory. Because of the time element in filtration, chemicals gradually lose their effectiveness and consequently slow down the filtering rate toward the end of each batch.

Recently Wallace and Tiernan, with the cooperation of Sparling Meter Co., designed and built a feeder combined with a meter which

*Superintendent of Plant, Pasadena, California.

can be depended upon to feed ferric chloride in any proportion to the rate of sludge flow. Such a machine has been very satisfactory in solving one of our problems, and is well built to withstand the corrosive effect of this chemical. The Wallace and Tiernan Feeder in combination with a Sparling Meter will prove a fine asset to any sewage works desiring accurate control for the use of ferric chloride.

Another installation this year, and one that we have needed for a long time, is a pair of comminutors. With such a name one ought to expect most anything, and they are living up to it. These comminutors, or grinders as we more often call them, are arranged in two channels controlled by two 48 in. gates. Each comminutor, 36 in. in diameter with $\frac{3}{16}$ in. slots, is driven by a 5 H.P. motor. Very rugged in construction, with large bearings above the water line, these machines run as smoothly as a clock. Each has a capacity of over 15 m.g.d., and in the six months they have operated have needed no repairs and very little attention.

Everyone asks what is wrong with a piece of equipment rather than the good features. In my opinion there is nothing wrong with these comminutors, and the only missing feature is a knife that will cut rags in small pieces. These comminutors do cut rags as easily as other materials in sewage, but the rags are cut in strings $\frac{3}{16}$ in. wide by one or two feet long. These strings are a nuisance as far as pump impellers are concerned, and the only remedy we have found is a bar screen behind or beyond the comminutors. Inspection of the stellite cutters indicate no chipping or apparent wear or dullness.

The cleanliness and improved appearance of this machinery over our old system is very noticeable.

Expense for screenings disposal is practically eliminated and the comminuted material has added about half a ton of dry sludge per day to our fertilizer output. Nitrogen content has remained the same as before the addition of this material, much to our surprise and advantage.

We have also put into service a new Oliver vacuum filter, with which most of you are familiar. It is practically the same as our other three, except for a few improvements. A new building now houses this equipment.

An addition to the plant in the near future is anticipated, increasing our capacity by approximately 3 m.g.d. This addition will include a mechanically cleaned bar screen.

AUTOMATIC CONTROL OF SKIMMERS, SLUDGE PUMPS, GAS ENGINES AND WASTE GAS

By H. M. ELY*

In the operation of a modern sewage disposal plant, it is necessary that we have a large amount of mechanical equipment, and the efficient operation of the plant depends largely on how well this equipment functions. The slogan of the National Implement Dealers a few years ago;

*Chief Operator, Disposal Plant, Ontario, California.

"Good equipment makes a good farmer better," surely applies to the sewage plant operator and his equipment.

When one man has complete charge of the operation of a plant, mechanical, laboratory, and other phases, it is necessary that he plan each detail of his work in order to have plenty of time to meet all routine duties.

With this in mind at our plant in Ontario, we have endeavored to make everything automatic as nearly as possible, and still maintain a high degree of efficiency in operation.

I want to speak of some of our automatic devices and explain how they function.

Our primary clarifier is equipped with an automatic skimmer and scraper, manufactured by the Hardinge Company. This is controlled by a General Electric twenty-four hour clock, making the trip across the clarifier once every hour from 7:00 A.M. to 9:00 P.M. and about once every two hours for the balance of the night, making a total of twenty trips over the tank in every twenty-four hours. This, together with the next device, of our own manufacture, keeps the primary clarifier in excellent condition.

In connection with our automatic skimmer and scraper, we have put on the side of the clarifier an electric switch which controls our sludge pump, the latter connected to the pump at the front end of the clarifier. Every time the skimmer passes this switch it starts the pump which runs for three and one-half minutes, or a total of ninety minutes each day. We have found that by following this schedule, we are enabled to keep our primary clarifier in excellent condition without overloading it at any time with supernatant liquor from the digester; which we all know is one of the serious difficulties encountered in the operation of activated sludge plants.

It is the writer's firm belief that upon the successful operation of the primary clarifier rests the operation of your whole plant, and it is with this end in view that we have placed this second device in operation. We have been more than pleased with the results obtained.

Another of our automatic fixtures performs with our gas engine. This engine is operated on a twenty-four hour basis, running an air blower. We knew the habits of gas engines, that at some unexpected time they might stop, especially when the attendant is away. We found it necessary to provide some means to start an electric motor and blower in case the engine should fail. First, we placed a check valve in the main air line leading from the engine, connecting it by a spring switch to our main motor and blower. If the engine stops, the check valve closes and the arm with the balance weight releases the switch and the electric motor starts, thus keeping up the supply of air to the aeration tanks. To date, this has functioned perfectly. On five separate occasions, I have returned to the plant and found the engine stopped and the electric motor carrying the load. This gadget alone has practically made our plant a one-man plant.

Our engine is further protected by an automatic temperature cut-out to prevent the engine from over-heating, as well as an automatic oil pressure gauge, which stops the engine if any obstruction comes in

the oiling system. The latter gauge has been one of the causes of the engine's stopping by reason of an oil line inside the engine coming loose and leaking. Serious damage probably would have been done on the engine if this device had not functioned.

Still another gadget disposes of our waste gas. On account of the varying quantity of gas from the digester, it was necessary to provide some means of taking care of it when in excess of our needs. We installed a lever check valve in the waste line and connected it to a trip lever on top of the gas holder. As the dome on the gas holder rises it opens the check valve, allowing the gas to escape to the burner. A pilot line attached behind the check valve keeps a pilot light burning at all times. In this way we have substantially lessened the danger of fire, and odor of escaping gas. It has also made it possible for us to pass all the gas we make through our meter. Thus we know each day just how much gas has formed, been used, and wasted.

These four automatic devices have made it possible to operate our plant not only efficiently, but economically, and this accomplishment makes the operator feel, as he leaves the plant, especially at night, when it is alone for twelve hours or more, that because of these devices, everything is functioning properly.

BLOWERS

By FRED WEST

The subject that has been wished on me for this program is blowers or compressors.

First, I will state what part blowers take in the operation of an activated sludge plant. The air produced by blowers is for a number of things. It keeps the solids in suspension, supplies oxygen to the bacteria, and also oxidizes the solids.

We have four Nash Hytor air compressors or blowers at the Lodi plant, including three No. 4 and one No. 7. The No. 4 compressors each have a capacity of 450 cu. ft. per min. at 10 lb. pressure, and the No. 7 has a capacity of 1,400 cu. ft. per min. at 10 lb. pressure.

Air is supplied to the sewage through pipe lines which connect to the bottom of the aeration channels, and is released through diffuser plates at a depth of 16 ft.

At the present time, we are using about 0.6 cu. ft. of air per gal. of sewage and getting very gratifying results. Our stability samples hold the color twenty days plus. The dissolved oxygen averages 4.3 p.p.m.

The accurate measurement of the air and sewage is very essential to the operation of an activated sludge plant. Until recently, air was measured by the rated output of the compressor, and the sewage was measured by a V notch weir.

Meters were installed at the time the plant was built in 1923, but did not give satisfactory results, so were abandoned. Recently, the meters have been reinstalled under the supervision of our city engineer, Clinton Henning, and are giving satisfactory results.

The diffuser plates are the original ones installed when the plant was built. We are contemplating installing new plates in one channel in

the near future, and then check results with the channels still having the old plates.

As for the efficiency of the Nash Hytor air compressors, they may not be of the highest type, but they do give a steady flow of clean air and do not require very much attention.

Recently, we overhauled one of the No. 4 compressors and put it back to its original efficiency. We also worked the Dorr screen over, and I think our troubles are over for some time. One end is closed tight, and a thrust bearing against the end of the shaft keeps the end face of the screen tight against the casting at all times.

BLOWER EXPERIENCE AT YOSEMITE

By RUSSELL C. WHITE*

The activated sludge plant in Yosemite National Park, which has been in operation since August, 1931, has four aeration units of the spiral flow type. Air is admitted to the bottom of each unit through Norton porous plates set in two rows the length of each tank. The effective depth of sewage in the tanks is 12 ft. Air lifts are used for returning sludge from the settling tanks.

In considering air compressor equipment several factors are important. The equipment must be thoroughly reliable and capable of maintaining uninterrupted service, the delivered air must be free of oil in order to avoid clogging of the porous plates, and the equipment must also be highly efficient, since the principal item of operating costs is that of compressing the air. At the time of construction of the plant, a recently developed, geared, high speed (21,000 r.p.m.), centrifugal compressor of a well known make was believed to meet the above conditions. Two units, each with a capacity of 425 cu. ft. per min., were installed. The operation of this equipment, however, was never entirely satisfactory and the blowers were exceedingly noisy, which was objectionable on account of the location of the plant. They were also very sensitive to power fluctuations and required much attention by the operators. The most serious difficulty encountered was with the bearings. No matter how frequently the bearings were greased they required replacing at frequent intervals and because they were made of special steel the cost was prohibitive. Frequent blower trouble resulted in improper aeration and finally it was necessary to clean the porous plates which became clogged at the surface because of these shutdowns.

In 1933 the above blowers were replaced with multi-stage, centrifugal compressors of the same make and with the same capacity but with a speed of 3600 r.p.m. Similar blowers have been in operation throughout the country for a number of years and are very dependable. Up to the present time no serious operating difficulties have been encountered. The bearings, which are widely used and inexpensive, are replaced yearly in order to avoid shutdowns during the summer months of peak loads. Although the new blowers are much larger and require more space than the original ones the operators find them easy to operate, not noisy and dependable.

*Junior Bacteriologist, National Park Service.

CALIFORNIA SEWAGE WORKS ASSOCIATION MEMBERSHIP

(As of July 1, 1937)

Allen, William A.
Supt. Pasadena Sewage
Disposal Plant
City Hall
Pasadena, Calif.

American Cast Iron Pipe Co.
Attn. W. R. Blair
55 New Montgomery St.
San Francisco, Calif.

Arndt, Charles
110 Winston St.
Los Angeles, Calif.
(Plumbing and Heating)

Arnold, G. E.
San Francisco Water Dept.
Millbrae, Calif.

Banks, Harvey O.
1811 Fulton
Palo Alto, Calif.

Banta, A. Perry
Assistant Engineer
110 So. Broadway, 4th Floor
Los Angeles, Calif.

Barnard, Archer F.
Quinton, Code & Hill —
Leeds and Barnard
601 West 5th St., Suite 905
Los Angeles, Calif.

Barr, H. R.
Operator, Hyperion Screening Plt.
Route No. 1, Box 302
Redondo Beach, Calif.

Bates, John S.
Consulting Engineer
3134 Eton Ave.
Berkeley, Calif.

Batty, F. A.
745 City Hall
Los Angeles, Calif.

Beardsley, C. W.
Bureau of Standards
City of Los Angeles
847 Kensington Road
Los Angeles, Calif.

Bell, Alexander
Western Sales Manager
Wallace & Tiernan Company
171 Second St.
San Francisco, Calif.

Benas, Ben
City Hall
San Francisco, Calif.

Berg, Wm.
416 Third St.
San Bernardino, Calif.

Beyer, A. Carl
District Manager
Wallace & Tiernan Company
171 Second St.
San Francisco, Calif.

Bishop, H. N.
Cons. Civil Engineer and
City Engineer, Sunnyvale and
Willow Glen
P. O. Box 587, Sunnyvale, Calif.

Blackman, J. W. B.
City Engineer—Director of
Public Service
City of Long Beach, City Hall
Long Beach, Calif.

Bowen, M. R.
Sewer Supt. City of Whittier
205 No. Greenleaf
Whittier, Calif.

Bowlus, Fred D.
Resident Engineer
Los Angeles Co. Sanitation Dist.
4th Floor, 110 So. Broadway
Los Angeles, Calif.

Brown, E. L.
Engineer, W.P.A.
124 No. Dillon St.
Los Angeles, Calif.

Brown, Kenneth W.
Sanitary Engineer
California Water Service Co.
829 No. Monroe St.
Stockton, Calif.

Browne, Arthur W.
623 Palo Alto Ave.
Mountain View, Calif.

Buck, J. H.
Street Supt.
516 Santa Barbara St.
Santa Paula, Calif.

Buckingham, Earl M.
Draftsman, City of Oakland
96 Zinn Drive
Oakland, Calif.

Burt, Austin
City Service Manager
City Hall
Ontario, Calif.

Byxbee, J. F.
City Engineer
City Hall
Palo Alto, Calif.

Castello, W. O.
Assistant Engineer
Div. of Water, City of Sacramento
Room 112, City Hall
Sacramento, Calif.

Castro, Albert J.
Supt. of Sewage Disposal Plant
724 Benton St.
Santa Clara, Calif.

Chamberlain, L. H.
District Manager
Water Works Supply Co.
417 So. Hill St.
Los Angeles, Calif.

Clark, John A.
511 So. Holly St.
Medford, Oregon

Clark, N. and Sons
Att. Bradley W. Wyatt
116 Natoma St.
San Francisco, Calif.

Collins, A. Preston
Grade III Engineer
County Surveyor's Office
400 Klinker Bldg.
Los Angeles, Calif.

Cleveland Public Library
Cleveland, Ohio

Compton, C. R.
Office Engineer
Los Angeles Co. Sanitation Dist.
4th Floor, 110 So. Broadway
Los Angeles, Calif.

Cook, Lawrence H.
Chemical Engineer
Secty., Menlo Park Sanitation Dist.
Box 696, Menlo Park, Calif.

Cook, Max E.
Pacific Lumber Company
100 Bush St.
San Francisco, Calif.

Cooley, E. C.
Chicago Pump Co.
Rialto Bldg., 625 Market St.
San Francisco, Calif.

Cortelyou, H. P.
Engineer, Disposal of Wastes
City of Los Angeles
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Los Angeles, Calif.

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Flexible Sewer Rod Equipment Co.
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Chicago Pump Company
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Asso. Engineer
Burns & McDonald
City Hall
Little Rock, Arkansas

Dalrymple, C. C.
Supt., Sewage Disposal Plant
2330 Earl Ave.
Long Beach, California

Davids, E. M.
Gladding, McBean & Co.
2901 Los Feliz Blvd.
Los Angeles, Calif.

Davidson & Fulmor
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3646 Seventh St.
Riverside, Calif.

DeMartini, Frank E.
Water Purification Engineer
San Francisco Water Dept.
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Derby, Ray L.
Asst. Sanitary Engineer
Dept. of Water and Power
207 So. Broadway
Los Angeles, Calif.

Dommes, Sid F.
244 Fifth St.
Richmond, Calif.

Eastman, T. F.
Asst. Engineer
701 City Hall
Oakland, Calif.

Eddy, Harrison P.
Metcalf & Eddy
1300 Statler Building
Boston, Mass.

Ellinger, Morris
Asst. Engineer
Lake Arrowhead, Calif.

Ely, H. M.
Chief Operator
City Hall
Ontario, Calif.

Fairbanks, E. G.
Health & Safety Commission
City of Manteca
Box 66, Manteca, Calif.

Fairbanks, Morse & Co.
Att. Geo. F. Ferwelling
Mgr. Pump Dept.
2401 Santa Fe Ave.
Los Angeles, Calif.

Farley, L. C.
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746 City Hall
Los Angeles, Calif.

Ferguson, E. R.
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Fitch, T. A.
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City of Los Angeles
826 Yale St.
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Foster, Herbert B., Jr.
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Berkeley, Calif.

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Fraser, A. F.
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1315 2nd Ave.
San Francisco, Calif.

Frick, A. L., Jr.
Wallace & Tiernan Co.
2311 E. 8th St.
Los Angeles, Calif.

Frickstad, Walter N.
City Engineer
803 City Hall
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City Engineer
City Hall
Pomona, Calif.

Gardner, R. T.
Wallace & Tiernan Co.
56 So. Third E St.
Salt Lake City, Utah

Gascoigne, George B.
Cons. Sanitary Engineer
1140 Leader Bldg.
Cleveland, Ohio

Gilkey, A. E.
Manager of Utilities
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Roseville, Calif.

Gillespie, C. G.
Chief, Bur. of Sanitary Engineering
State Dept. of Public Health
3093 Life Sciences Bldg.
Berkeley, Calif.

Goodridge, Harry
City Engineer
City Hall
Berkeley, Calif.

Goudey, R. F.
Sanitary Engineer
Water & Power Dept.
Box 240, Arcade Annex
Los Angeles, Calif.

Grahek, J. L.
701 City Hall
Oakland, Calif.

Gray, Harold F.
Sanitary & Hydraulic Engineer
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Grunsky, Eugene L.
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833 Market St.
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Hall, James D.
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City of Los Angeles
218 W. Mariposa Ave.
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Henry, B. F.
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Herb, Cornelius L.
Chemist, Purification Division
City Water Dept.
Room 112, City Hall
Sacramento, Calif.

Hill, Chas. L.
City Engineer
City Hall
Reno, Nevada

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National Park Service
Yosemite, Calif.

Hitchner, A. H.
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403 City Hall
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Holfelden, J.
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Homeyer, William H.
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Hommon, H. B.
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U. S. Public Health
210 Federal Office Building
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Hoskinson, Carl M.
Chief Engineer
Division of Water
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Sacramento, Calif.

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University of California
Room 11, Engineering Bldg.
Berkeley, Calif.

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Room 216, Lyon Bldg.
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San Joaquin Local Health Dist.
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Junior Engineer, Div. of Water
City of Sacramento
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Sacramento, Calif.

Jewell, H. W.
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306 West Ave. 26
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(361 N. Laurel Ave., L. A.)

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Kinsman, Frederick
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725 Walnut Ave.
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Kolb, Fred W.
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Krohn, William
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Langelier, Wilfred F.
University of California
Asso. Prof. in Sanitary Engineering
Civil Engineering Laboratory Bldg.
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Lawton, Ralph W.
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Lee, Chas. H.
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Marx, Charles David
Consulting Engineer
357 Kingsley Ave.
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Miick, Fred
361 So. Anderson St.
Los Angeles, Calif.

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Supt., Division of Water
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Sacramento, Calif.

Molitar, Paul
4 Willow Street
Chatham, New Jersey

Munson, Laura A.
Sanitary Engineer
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Norman, Chas. S.
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O'Connell, Wm. J.
Wallace & Tiernan Co.
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Olsen, Louis
Health Officer
City of Palo Alto
City Hall
Palo Alto, Calif.

Ongerth, Henry J.
County Sanitary Engineer
Monterey County
Box 397
Salinas, Calif.
(593 8th Ave., San Francisco)

Pacific Foundry Co.
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Palmer, Harold K.
Chief Draftsman
Los Angeles Co. Sanitation Dist.
4th Floor, 110 So. Broadway
Los Angeles, Calif.

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Los Angeles City
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Parsons, Francis W.
Assistant Engineer
Los Angeles City Engineering Dept.
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Patterson, Richard L.
City Engineer
Water & Street Supt.
City Hall
Newport Beach, Calif.

Payton, Lyle
City Engineer
City Hall
Stockton, Calif.

Phelps, B. D.
Assistant City Engineer
City of San Diego
City Hall, 5th & G Sts.
San Diego, Calif.

Phelps, Tracy I.
Engineer, Los Angeles County
Surveyor's Office
400 Klinker Bldg.
Los Angeles, Calif.

Pierce, C. L.
District Representative
Great Western Electro-Chemical Co.
1925 Euclid Ave.
San Marino, Calif.

Pleasanton, Town of
Pleasanton, Calif.

Pomeroy, Richard
Chemist, Los Angeles County
Sanitation Districts
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Harbor City, Calif.

Polich, Theodore P.
Vice-President
United Concrete Pipe Corp.
Box 1, Station "H"
Los Angeles, Calif.

Porter, H.
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City Hall
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Post, Fred W.
Supt. Sewage Plant
Route No. 3, Box 433
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Ramseier, Roy E.
Deputy County Health Officer
Imperial County
760 Lenkey Ave.
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Ranagan, Fred E.
Pardee Engineering Co.
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City of Fresno
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Fresno, Calif.

Rawn, A. M.
Assistant Chief Engineer
Los Angeles Co. Sanitation Dist.
4th Floor, 110 So. Broadway
Los Angeles, Calif.

Reed, Chas. A.
7th Floor, City Hall
Oakland, Calif.

Reed, George W.
Civil Engr. National Park Service
Mineral, Calif.

Reinke, Edward A.
Senior Sanitary Engineer
State Dept. of Public Health
3093 Life Sciences Bldg.
Berkeley, Calif.

Reynolds, Leon B.
Prof. of Hydraulic and Sanitary Engineering
Civil Engineering Dept.
Stanford University, Calif.

Ribal, Raymond Robert
Designing Draftsman
701 City Hall
Oakland, Calif.

Roberts, W. C.
Director, Pacific Engineering Laboratory
548 Call Bldg.
San Francisco, Calif.

Robinson, W. S.
Assistant Operator
Los Angeles County Sanitation Districts Disposal Plant
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Sanchis, Jos. M.
Assistant Sanitary Engineer
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Los Angeles, Calif.

Sauer, Victor W.
Draftsman, 701 City Hall
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Senseman, Wm. B.
Pacific Coast Manager
Combustion Engineering Co.
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Los Angeles, Calif.

Schapp, A.
Attorney
501 Hobart Bldg.
San Francisco, Calif.

Schuck, H. W.
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Burlingame, Calif.

Shaw, Paul A.
450 McAllister St.
San Francisco, Calif.

Shearer, A. B.
Marin Sanitary District No. 1
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San Anselmo, Calif.

Sherman, W. R.
Box 102
Newman, Calif.

Shook, H. E.
Sales Dept.
Great Western Electro-Chemical Co.
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San Francisco, Calif.

Singer, Lewis P., Jr.
Asst. City Engineer
Box 42
Lodi, Calif.

Skinner, John F.
Consulting Sanitary Engineer
3333 West 4th St.
Los Angeles, Calif.

Skinner, W. V.
Supt. Water & Sewer Dept.
Box 22, City Hall
Escondido, Calif.

Slane, Norman F.
Meter Service Inspector
Los Angeles Dept. of Light & Power
3623 So. Arlington Ave.
Los Angeles, Calif.

Smith, Alva J.
Consulting Engineer
Black & Veatch
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Smith, Chester A.
Consulting Engineer
107 W. Linwood Blvd.
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Smith, H. G.
Engineer of Sewer Design
and Plant Operation
Room 745, City Hall
Los Angeles, Calif.

Smith, J. F.
Vice-President in charge of Sales
Great Western Electro-Chemical Co.
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San Francisco, Calif.

Smith, W. D.
Assistant Engineer in office of
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Stevenson Chemical Co.
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Stites, Howard I.
City Engineer
City Hall
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Burbank, Calif.

Straver, Elmer C.
Civil Engineer
204 So. Olive Ave.
Alhambra, Calif.

Stuart, Archer B.
City Engineer
City of Healdsburg
(P. O. Box 21)
Healdsburg, Calif.

Studley, E. G.
Assistant Civil Engineer
705 City Hall
Los Angeles, Calif.

Sommers, William F.
Screening Plant Operator
10728 Westminster Ave.
Los Angeles, Calif.

Tegtmeyer, L. G.
Sanitary Engineer
City and County of San Francisco
368 City Hall
San Francisco, Calif.

Tennant, Carl F.
Supt. of Operation
Los Angeles County Sanitation
District Treatment Plant
216 Santa Fe Ave., Apt. "B"
Long Beach, Calif.

Thomas, Franklin
Professor of Civil Engineering
Calif. Institute of Technology
Pasadena, Calif.

Taylor, Alva A.
2120 Cherry Ave.
Long Beach, Calif.

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University of Southern Calif. Library
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University of California
Div. of Serials & Exchanges
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Vaughan, E. A.
Manager, Light & Water Dept.
K. of P. Bldg., City Hall
Lompoc, Calif.

Waggoner, E. R.
Sales Dept.
Pacific Clay Products
306 W. Avenue 26
Los Angeles, Calif.

Wakeman, C. M.
Testing Engineer
Los Angeles Harbor Dept.
1413 No. Edgmont St.
Los Angeles, Calif.

Walters, Grover L.
Supt. of Sewer & Water Dept.
City of Fullerton
123 W. Wilshire Ave.
Fullerton, Calif.

Warrington, H. E.
Designing Engineer
Los Angeles County Sanitation Dist.
4th Floor, 110 So. Broadway
Los Angeles, Calif.

White, Russell C.
National Park Service
Yosemite National Park, Calif.

Whitehead, Richard S.
Regional Sanitary Engineer
Resettlement Administration
1009 Palm Ave.
San Mateo, Calif.
Warren, A. K.
Chief Engineer
Los Angeles County Sanitation Dist.
4th Floor, 110 So. Broadway
Los Angeles, Calif.
Watkins, H. H.
Engineer & Secretary
Auckland & Suburban Drainage Bd.
P. O. Box 208
Auckland, New Zealand
Weed, Sam A.
Draftsman
Golden Gate International Exposition
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Weppener, Carl J.
Supt. of Streets & Sewers
183 N. Rosanna St.
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West, Fred
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308 No. 10th St.
Colton, Calif.
Western City Magazine
W. R. Updegraff, Editor
448 So. Hill St.
Los Angeles, Calif.
Wintersgill, A. T.
General Sales Manager
Pacific Clay Products
Box 145, Station A
Los Angeles, Calif.
Woodward, R. D.
Plant Operator & Mechanic
City of Laguna Beach
463 Myrtle St.
Laguna Beach, Calif.
Young, John T.
Principal Asst. Testing Engineer
City of Los Angeles Bur. of Standards
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Wyman was a member of the first board of directors of the Association and was a constant attendant at the annual meetings.

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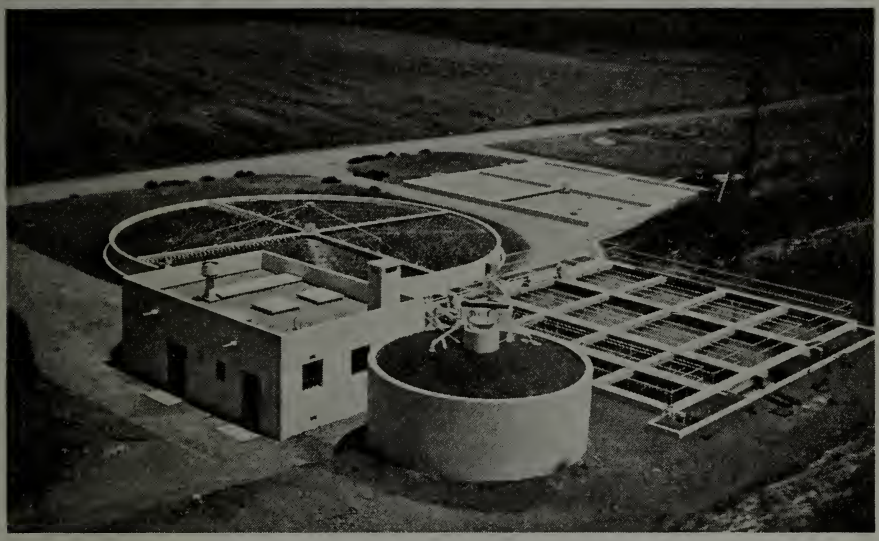
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CALIFORNIA SEWAGE WORKS JOURNAL

Official Publication of the California Sewage Works Association

Vol. X :: 1938 :: No. 1

Minutes of the Tenth Annual Convention
at San Jose, California
September 13 and 14, 1937

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Symposium on Plant Operation

•

Electricity for Sewage Plant Operators

•

Bacteriology in Relation to Sewage Disposal

•

Charges for Sewer Connections from Outside
Areas to City Sewer Systems

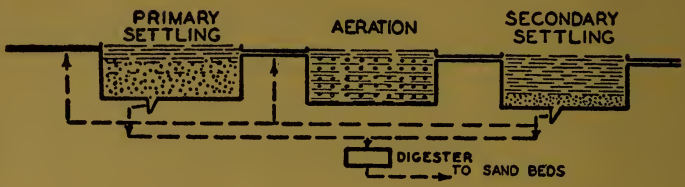
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Civic Affairs

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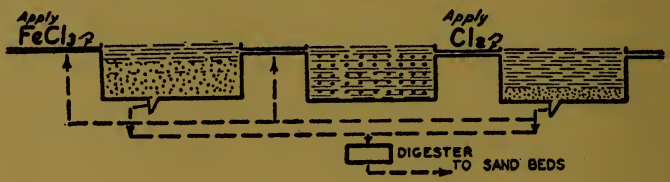
Committee Reports

CHEMICAL TREATMENT CAN STOP ODORS AND SAVE ON OPERATING COSTS



This is the sewage treatment plant in a well-known California city of 10,000 population. Sewage contains considerable amounts of packing plant wastes. Using the activated sludge process as indicated, the plant has difficulty in delivering a clear effluent. Odors exist at the plant because of the overload of organic material going to the aeration tank. Operation is unsatisfactory and costly as a result.

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ALEXANDER BELL 171 Second St., San Francisco

Second Vice-President

H. G. SMITH 745 City Hall, Los Angeles

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California Sewage Works Journal

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The California Sewage Works Association is not responsible, as a body, for the supposed facts and opinions advanced in any of the papers, discussions, or articles published in this Journal. Discussion of all papers is invited.

Vol. X 1938 No. 1

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TENTH ANNUAL CONVENTION

San Jose, September 13 and 14, 1937

PROGRAM

Monday, September 13

Morning

8:00—Registration—Hotel Sainte Claire.
9:00—Leave San Jose Municipal Auditorium.
9:30—Inspection of Pratt-Low Cannery at Santa Clara.
10:15—Inspection of Santa Clara Sewage Treatment Plant—Sifeed clarifier, two stage Dorr digester, land irrigation.
11:15—Inspection Los Gatos Sewage Treatment Plant—One of the oldest Imhoff, trickling filter plants in the State.

Luncheon

12:15—At Hotel De Anza.

Afternoon

2:00—Discussion of the Sewage Treatment Plants Visited.
2:30—Symposium by Operators, Engineers and Equipment-men on Operating Problems.
Discussion led by:
Operators: Fred West, Stockton; Albert Castro, Santa Clara; H. M. Ely, Ontario; J. C. Clark, Huntington Beach; J. H. Van Norman, Los Angeles; John A. Clark, Berkeley.
Engineers: C. C. Kennedy, San Francisco; Harold F. Gray, Berkeley; F. S. Currie, Los Angeles; A. H. Koebig Jr., Los Angeles; Ben Benas, San Francisco; H. G. Smith, Los Angeles.
Equipment-men: Earl Kelly, L. H. Chamberlain.

Dinner

7:00—At Lo Curta's.
Hollis R. Thompson, City Manager of Berkeley will speak on "Civic Affairs." Engineers and Planners' Section of the League are invited to attend. Ladies, of course, are welcome.
Entertainment.

Tuesday, September 14

Morning

7:00—Directors' Breakfast.
9:00—Business Meeting.
10:00—"Electricity for Sewage Works Operators" by George A. Weber, of Palo Alto.
11:00—"Bacteriology in Relation to Sewage Disposal" by Ray L. Derby, of Los Angeles.

Luncheon

12:30—Main Dining Room, Hotel Sainte Claire.

Afternoon

Joint Session with the Engineers' Section of the League of California Municipalities.
2:00—"Uses of Activated Sludge Plant Effluent in Golden Gate Park, San Francisco" by Prof. Chas. Gilman Hyde, of University of California.
3:00—"Supervision of Treatment Plant Operation by the Designing Engineers" by George A. Parkes, of Los Angeles.
4:00—"Charges for Sewer Connections from Outside Areas to City Sewer Systems" by Jean L. Vincenz, of Fresno.
Discussion by:
J. F. Byxbee, Palo Alto.
Lloyd Aldrich, Los Angeles.
W. L. Popp, San Jose.
5:00—Adjournment.
Committee on Local Arrangements:
W. L. Popp, chairman.
Harold Flannery.
Albert Castro.

ANNOUNCEMENT OF THE SPRING CONFERENCE CALIFORNIA SEWAGE WORKS ASSOCIATION SAN DIEGO, CALIFORNIA APRIL 11-12, 1938

Headquarters U. S. Grant Hotel

FIRST DAY—APRIL 11

All day of April 11 will be given to a detailed consideration of operators' problems. The problems selected for discussion will be apart from engineering design and will deal with the improvements operators make in a plant which are not ordinarily expected to be supplied by the engineer. It is planned at the coming conference to seek cooperation along constructive lines to the end that operation may be improved by suggestions from both operators and engineers. Needless to say, there will be a special effort at the Conference to bring up to date everything new in connection with sewage disposal.

SECOND DAY—APRIL 12

April 12 will be an all day caravan, so broken up, however, to be highly interesting and not tiring. In the morning there will be a boat trip on the San Diego harbor, inspection of the outfalls, and a talk aboard ship on sewage disposal for San Diego. Ample time will be provided to return to hotels for lunch, pack, and form a caravan for the trip to Los Angeles by way of the scenic coast route. Stops will be made at the following plants: Laguna Beach, Huntington Beach, and Seal Beach. Laguna Beach is a new activated sludge plant with many new innovations. Huntington and Seal Beaches are separate sludge digestion plants of up to the minute design, whose operators are proud of the progress they have made in operation improvements.

There may be some in the caravan who will desire to visit other plants en route, such as Carlsbad, Oceanside, Doheny Park, Newport Beach, Orange County Screening Plant, and Signal Hill.

Mr. Phelps promises interesting entertainment features during our San Diego stay.

There is every reason to believe that the San Diego Conference will be one of the most constructive and instructive yet held by the California Sewage Works Association.

MINUTES OF THE TENTH ANNUAL CONVENTION
of the
CALIFORNIA SEWAGE WORKS ASSOCIATION

San Jose, California — September 13-14, 1937

The Tenth Annual Convention of the California Sewage Works Association was held in San Jose, California, September 13-14, 1937; jointly with the League of California Municipalities.

San Jose is situated at the most southerly end of the San Francisco Bay, in the Santa Clara Valley, which valley is famous for its prunes and fruits.

The Association's inspection "caravan" on the first day of the convention was again limited to one-half day, which allowed more time for sessions, but still allowed ample time to inspect the large Pratt-Low cannery at Santa Clara, where pears, peaches and tomatoes were being packed, and two small treatment plants.

After an hour observing the various canning processes, the caravan, consisting of around 150 members and guests, proceeded to the Santa Clara sewage treatment plant, which receives the wastes from the above cannery, and consists of a clarifier with separate sludge digestion. The effluent from the plant is used for the irrigation of such crops as sugar beets and seeds.

Continuing, the caravan arrived at the Los Gatos treatment plant at 11:00 A.M. This plant is one of the oldest Imhoff-Trickling Filter plants in the state and the only plant where the tanks and filters are covered for odor control. The gas is burned.

Luncheon was had at the De Anza Hotel with eighty in attendance, mostly members.

THE PROGRAM

The afternoon of the first day was given over to a Symposium on Operating Problems, which brought out many important operating difficulties and the suggestion to the operator, engineer and equipment man that many of the difficulties can be eliminated by mutual cooperation. Seventy-five attended this session.

Hollis R. Thompson, City Manager of Berkeley and Past President of the League of California Municipalities, spoke on the subject "Civic Affairs" at the dinner meeting Monday evening. His theme was: Inhabitants of cities are demanding increasingly more service at a reduced cost, and each official's duty is to render the best service possible with the funds made available, to acquaint himself with all the functions of the city, and to advise the citizen of the services he receives. Cooperation of various bureaus and political subdivisions, careful planning and foresight, he said, will determine the future prosperity, health and happiness of a community.

The Engineers and Planners Section of the League were invited to attend the dinner meeting. There were two-hundred forty members and guests present.

The morning session of the second day was opened with Committee Reports. The Committee on Certification and Schools reported that forty-nine sewage treatment plant operators had applied for certification and had been rated as Grade I, II, or III. The short school for plant operators held at the University of Southern California June 14 to 18, inclusive, was very successful, and plans are now being made for a short school in the northern part of the state during the summer of 1938.

The Auditing Committee, consisting of F. S. Currie, Chairman, Ray L. Derby and N. A. Knoedler, reported accounts of the Association correct and in order.

The Nominating Committee, consisting of Carl Hoskinson, Chairman, Fred Bowlus, and G. Kjellburg, reported placing the following members in nomination, to succeed retiring officers, and they were unanimously elected: President, R. F. Goudey, Sanitary Engineer, Dept. of Water and Power, Los Angeles; First Vice-President, Alexender Bell, Western Sales Manager—Wallace and Tiernan Company, San Francisco; Second Vice-President, H. G. Smith, Engineer of Sewer Design, Los Angeles; Secretary-Treasurer, R. R. Ribal, Oakland; Director (5 years), B. D. Phelps, Asst. City Engineer, San Diego; Board of Control, Austin Burt, City Service Manager, Ontario.

The two papers of the morning session were of an informational character for plant operators. Mr. George A. Weber explained "Electricity for the Sewage Works Operator" in a chalk talk with many sketches and diagrams illustrative of how motors, controls and switches function and closed with a warning of the dangers of carelessness when dealing with electrical currents. Mr. Ray L. Derby in his paper "Bacteriology in Relation to Sewage Disposal" omitted nothing in the field of bacteriology that applies to sewage treatment.

Three papers were presented at the afternoon session, which was conducted jointly with the Engineers' Section of the League. There were one-hundred twenty-five in attendance. Professor C. G. Hyde's paper on "Uses of Activated Sludge Plant in Golden Gate Park," was illustrated with lantern slides showing the many lakes, waterfalls, rivulets and ferny dells created by the use of effluent of the 500,000 gallon activated sludge plant located in the park. Mr. George A. Parkes discussed the "Supervision of Treatment Plant Operation by the Designing Engineer" indicating procedures that may result in establishing a fundamental basis of operation. The final paper of the session by Jean L. Vincenz on "Charges for Sewer Connections from Outside Areas to the City Sewer Systems" discussed by J. F. Byxbee, Lloyd Aldrich and W. L. Popp, was the first open discussion of this important problem to California cities.

R. R. RIBAL, Secretary-Treasurer

PROGRESS REPORT OF SUB-COMMITTEE ON CERTIFICATION

August, 1937

In accordance with instructions approved at the Santa Monica Convention of the California Sewage Works Association, your Sub-Committee on Certification for Operators formulated and sent out a printed letter of explanation of certification together with an application for certificate to all known operators and cities having sewage treatment plants in California.

At the present time 49 applications have been received. It is noted that 65% of the applications are from Southern California. Eight of the plants represented by the operators are activated sludge plants, 16 from separate sludge or Imhoff tanks, 10 from a screening plant, 2 from a sprinkling filter plant, and 13 general supervision.

Before issuing certificates which should start immediately, it is hoped that the Association will adopt a seal which can be used to imprint on the certificate.

Operators have until September 1, 1937 in which to apply for certification without examination.

Respectfully submitted,

W. A. ALLEN
A. C. BEYER
R. F. GOUDEY, Chairman

PROGRESS REPORT ON SUB-COMMITTEE ON SHORT SCHOOLS

August, 1937

As a result of cooperation with the University of Southern California, two activities of interest to Sewage Treatment Plant Operators have been inaugurated.

The first, the establishment of a Certificate Degree conferred by the University of Southern California on completion of certain required courses of instruction. The courses are given in connection with the Civic Center Division of the University of Southern California and each course runs from 5:40 P.M. to 8:00 P.M. once weekly for twelve weeks during three quarters.

The second activity was a Joint Operators School for Water and Sewage Plant Operators given June 14-18, inclusive, 1937, at the Institute of Government Week at the University of Southern California. The course includes parallel and joint sessions covering review of treatment processes, laboratory procedures, mechanical operation suggestions, routine operation, and round table discussions. There were three morn-

ing and three afternoon sessions. The cost of the course was $10 per person receiving $200 or more per month and $5 for those receiving a lower salary. Announcements will be advertised for a similar school in Berkeley for next year.

Respectfully submitted,

R. F. GOUDEY, Chairman
H. F. GRAY
A. P. BANTA
J. I. BALLARD
W. R. UPDEGRAPH

REPORT OF C.S.W.A. COMMITTEE ON INVESTIGATION OF METHOD AND PROCEDURE TO BE FOLLOWED IN MAKING THE ANNUAL AWARD OF MERIT

The Committee met on August 25, 1937, and concluded as follows:

(A) That the presentation of the Award of Merit be continued for a period of not less than five years, at the expiration of which time the entire affair may be reconsidered.

(B) That the Committee on Award consist of the responsible operators of the last three Plants which have been awarded the plaque.

(C) That no Plant shall be eligible for re-award of the plaque until the expiration of a period of three years following prior award.

(D) That, in addition to the plaque, the principle of the cash award be re-established and that the award be divided as follows:

(1) To the Plant having the best record and to which, in the opinion of the Committee, the first award should go, the plaque and twenty-five dollars be presented to the operator;

(2) To the second best Plant there be presented a certificate stating, in effect, that it was judged second in the contest, plus fifteen dollars cash award;

(3) To the third best Plant a certificate stating, in general, that it was judged third in the contest, plus a ten-dollar cash award.

(E) That the following be requirements prerequisite to entering the contest:

(1) The Plant shall have an unrevoked permit to operate from the California State Board of Health.

(2) The operator shall have been certified by the appropriate committee in C.S.W.A.

(3) The Plant shall reasonably meet the requirements of the treatment process employed.

(F) The Award of Merit shall be made at the annual dinner at the annual meeting instead of at the Spring conference as in the past.

(G) The Committee on Award shall consider the Plant and the operator in the light of the following:

(1) Ingenuity of the operator in improving results or developing useful operation and/or maintenance improvements; new or unique methods, adaptation of other improved methods to his plant or process; and/or

(2) Public confidence and civic support gained by the operator as evidenced by favorable publicity and general improvements to the Plant.

(H) The operator shall present ample evidence substantiating his statements.

(I) The data covered by the report of the operator shall include as long a period of operation as the operator may desire but in any event shall be for not less than one year prior to the date the sought-for award is made.

(J) The Association's Secretary shall annually, prior to July 1st, mail to each operator in responsible charge and his principal, an invitation to participate in the contest for the annual Award of Merit.
The operator in responsible charge, or his principal, shall respond to the invitation, signifying his intention to enter prior to the following September 1st.

(K) The Committee on award shall fix the time and place for its annual meeting which shall not be held prior to September 1st each year, and may adjourn from time to time and from place to place, but shall consider the evidence presented by each contestant. It is intended that the Award Committee may meet at any time or times following September 1st and prior to the annual dinner at the annual meeting, and shall adjust the meeting dates to the convenience of its members and the Plant representatives or operators. It is not intended that the Committee on Award or members shall, of necessity, visit the Plants entered in the contest.

(L) At such annual meeting of the Committee on Award the Plant representatives shall be interviewed separately and the statements and evidence of each considered by the Committee on Award in making its findings and the said Committee shall complete its findings prior to the annual dinner meeting held customarily on the evening of the first day of the Annual Association meeting.

Respectfully submitted,

WM. A. ALLEN, Chairman
R. F. GOUDEY
A. M. RAWN

CALIFORNIA SEWAGE WORKS ASSOCIATION

Report of the Secretary-Treasurer Sept. 14, 1937

BALANCE ON HAND SEPT. 11, 1936			$ 815.27
CASH RECEIPTS:			
Membership Dues	1936	$ 11.00	
	1937	439.00	
	1938	2.00	
Subscriptions	1936	1.00	
	1937	2.00	
Refund Fed. Sewage Wks. Assn.		6.00	
Fees from Applicants for Certification		50.00	
Journal Advertising		482.50	
Journal Reprints		43.78	
			1,037.28
TOTAL RECEIPTS			$1,852.55
CASH DISBURSEMENTS:			
Printing—Mailing Jl. Vol. 8, No. 2		$ 293.65	
Printing—Mailing Jl. Vol. 9, No. 1		284.89	
Membership Dues,)	1936	12.00	
Federation Sewage Wks.)	1937	325.50	
Stenographic and miscellaneous		73.38	
Printing—stationery—postage		128.07	
Journal Reprints		43.78	
Checks returned unpaid		3.00	
Printing, etc., acct. certification		54.04	1,218.31
CASH ON HAND SEPT. 14, 1937			$ 634.24
Accounts Receivable			97.50
TOTAL ASSETS			$ 731.74

The publication of Vol. 9, No. 2, of the Journal has been contracted for but bills have not been received.

Total number of paid memberships to date—220.

FINANCIAL REPORT
COMMITTEE ON CERTIFICATION

RECEIPTS:	
Fees collected	$ 49.00
CASH DISBURSEMENTS:	54.04
DEBIT	$ 5.04

All postage incidental to the Committee has been paid from Association funds.

Respectfully submitted,

R. R. RIBAL
Secretary-Treasurer

SEWAGE PLANT OPERATION AND PROBLEMS AT SANTA CLARA, CALIFORNIA

By ALBERT J. CASTRO, JR.*

The sewage plant at Santa Clara consists of two hand cleaned bar racks, a Dorr Clarifier, and primary and secondary separate sludge digestion tanks, both units also Dorr equipment.

The plant serves a population of 7,000 people, two canneries, three packing houses, a walnut packing factory, a tannery, and two small creameries.

The average flow is 1,100,000 gallons per day during the fruit season, 756,000 gallons per day during the spinach canning and 560,000 gallons per day when the cannery is not operating.

The plant effluent is used for broad irrigation on a 236 acre surrounding farm. Its manurial value has been well shown by the fact that at one time on certain parts of the land only an extremely poor sugar beet, the size of a turnip, could be grown. After a year's watering with the plant effluent, beets with a diameter of from four to five times that of the original are now grown. Besides sugar beets lima beans, alfalfa, and cucumber for seed are grown.

Of the aforementioned trade wastes the greatest difficulty arises from the handling of the cannery waste, of secondary importance is the walnut packing house whose waste is extremely high in Chlorine at certain periods of the packing season, which fortunately is only a month or so in length. For example at one time after a four hour contact period the influent sewage had a residual Chlorine content 12.00ppm (Ortho Toluidine Method.) As a result of this high Chlorine content during the packing season the greater part of the bacterial action in our digestors ceased so that we had practically no gas production for twenty-five days during the month of October.

The plant has been in operation since June, 1936. The first problem confronting the operator was that of a satisfactory pumping schedule during the cannery season. Acting upon experiences obtained at other plants handling fruit wastes it was attempted to remove sludge from the sedmentation tank almost as rapidly as it was formed by pumping all the sludge from the Clarifier every hour from 8:00 A.M. to 6:00 P.M. This method proved highly disastrous. The effluent from the second digestion tank, which returns to the Clarifier where it is diluted before leaving the plant, contains a rather high volume of dissolved gases, which buoyed the sludge and caused it to rise to the surface of the Clarifier.

The pH of the secondary effluent being 6.8 soon induced an acid fermentation in the settling basin.

*Chief Operator.

These two factors resulted in the rising of all sludge to the surface of the tank, where it remained. Large bubbles of gas from 3 to 6 inches in diameter formed on the surface of the tank. Besides defeating the operation of the Clarifier and producing an extremely strong, sour odor which could be discerned a half-mile down wind, our suspended solid and B.O.D. reduction were found to be decreased by 13% and 30% respectively. At one time the Clarifier effluent was found to be 36.0 ppm higher in B.O.D. than the raw sewage.

Pumping twice daily was attempted with the same result as above due to the nature of the sludge.

Samples were taken of the influent sewage in Imhoff cones. It was found that practically complete precipitation of settleable solid occured in the first half-hour. At the end of two hours the sludge arose to the surface, buoyed by its own formed gases; some sludge remained at the surface while the remainder again settled to the bottom, only to rise again 20 minutes later.

Following these results pumping sludge from the Clarifier every two hours from 8:00 A.M. to 6:00 P.M. for a total of 6375 gallons resulted in satisfactory operation. Odors are now at a minimum and although some dark colored sludge still exists on the Clarifier surface it is not the strong, sour smelling, yellow sludge of before.

We now obtained with a sewage of strength in:

Suspended Solids 347.6 ppm a reduction of 57.12%
Biochemical Oxygen Demand 765.5 ppm a reduction of 27.2%
Oxygen Consumed 801.9 ppm a reduction of 61.3%
during the fruit season.

When the cannery is not in operation most satifactory results have been obtained by pumping sludge twice daily once in the morning and once in the afternoon for a total of 2700 gallons. We then obtained with a sewage of strength in:

Suspended Solids 381.0 ppm a reduction of 70.9%
Biochemical Oxygen Demand 490.3 ppm a reduction of 42.5%
Oxygen Consumed 446.0 ppm a reduction of 46.9%

A hand cleaned bar rack with 2-inch openings was originally used for the removal of large solids. However, this removed only a small percentage of sticks and rags, the remainder of which passing through caused a continual daily clogging of the scru-feed centrifugal sludge pump.

Upon the installation of a second rack also with 2-inch openings, a foot in front of the original rack, with bars so arranged as to be directly opposite the openings in the first racks, the clogging of the sludge pump has been greatly reduced.

In the operation of our digestion tanks we have as yet been unable

to reach the recommended pH. of 7.4 despite constant daily addition of lime during the first eight months of operation, for an amount equal 12.0 tons.

Due to mechanical trouble we have not been able to maintain a constant temperature of 86.0° Fahrenheit (30.0°C.) throughout this time. Either this, the nature of the sludge, or the time which the digestors have been in operation may be the reason for the low pH. of 6.8.

The average temperature of our digestors throughout the past year has been 77.0° Fahrenheit (25.0°C.).

This year we by-passed the sewage for seven weeks for painting and repairing the plant, after which time we found the pH. of the primary digestor to be 7.0. A quantity of lime theoretically necessary to bring the pH. up to 7.5 was added. After two days' operation the pH. again dropped to 6.8.

Our data on digestion when the cannery is in operation is incomplete at the present time; however, when the cannery is not in operation sludge leaving the secondary digestor has the following analysis:

Moisture	92.9%
Solids	7.1
Volatile Solids	57.1
Fixed Solids	42.9

The high hydrogen sulphide content of the disgester gas has seriously corroded our boilers. A scrubber is to be installed which will remove this impurity.

It is the belief of the author that with such a high percentage of hydrogen sulphide, in the future with an increase in the gas production and no great change in chemical composition, it may be commercially feasible to treat the resulting scrubber solution and obtain a sulphur sludge of a rather high commercial value. This sulphur sludge can then be put in wooden bins to dry; however, because of its fine colloidal state all the moisture is never thoroughly removed, so that it remains as a wet sludge.

Because of its extreme fineness it is particularly effective in the prevention of green mould and control of the red spider in that it adheres very firmly to the leaf and is not easily washed off. It can also be used mixed with the ordinary sulphur, used in spraying, quite effectively.

PROBLEMS AND THEIR ANSWERS AT THE ONTARIO ACTIVATED SLUDGE PLANT

By H. M. ELY*

In the operation of a sewage disposal plant, whether one of the newer types or one of the older, the operator is bound to meet with problems—some small, some large—and what may be a problem at one plant never bothers at another, while some are common to all plants.

In my paper I want to discuss three problems, one common to all plants as far as I can find out, and two that, so far as I know, have been problems for Ontario alone. First, the problem of bulking of the activated sludge. After watching and experimenting with my plant, I am convinced that there are two kinds of bulking: first, one caused by too little air compared to the amount of sludge carried and, second, that caused by the addition of some foreign substance into the plant which destroys the equilibrium among the bacteria. At our plant the second kind has been brought about by wastes from the Orange By-Products Plant on several occasions. In either case the problem resolves itself into one of specific gravity, and as you follow this discussion you will find why I arrive at this conclusion.

In the first instance, the cause is either negligence on the part of the operator or else comes from the desire of someone to conserve the power costs by cutting the air supply below the safety line, and the saving made at this time is paid out later in correcting the error. The remedy for this kind of bulking as a rule is not hard to find. Reduce your activated sludge and increase the air and the trouble generally clears in a day or two.

In the case of the foreign substance such as has been mentioned, this remedy is slow to act. In the winter of 1936 the City Manager informed me that the Rotary Club at Upland was to pay us a visit. Our effluent was very fine. Five days before they were to come we received a load of orange syrup from the Orange By-Products. That immediately brought on a severe case of bulking. What to do! Time was too short to clear it by the addition of air and the reduction of the sludge and, after experimenting with various ideas, I decided to try adding fine clay soil to the tanks. On Saturday afternoon, two days before our guests were to arrive, I sprinkled six wheelbarrows of soil in the various aereators. Sunday morning I had as clear an effluent with no bulking as the plant had ever turned out. Four times since then it has been necessary to do the same thing, and it has never failed to clear up the problem.

I am satisfied in my own mind that, while there may be long names applied to the bacteria that causes bulking or that is found in the sludge at these times, the answer lies in the specific gravity of the mixture. It has ceased to be a problem at the Ontario Plant.

*Chief Operator.

The second problem came with the month of January of this year. Those of you who reside in Southern California remember the smudge of January. The oil and the smoke in the air seriously affected the filter plates in our aereators, and the pressure on our air lines began to rise. Ordinarily, we use about 4.5 pounds of pressure, but during this period it rapidly advanced to 8 pounds. The increase meant increase of power and costs with lower efficiency. We were unable to find anyone who had had a similar experience and, after studying the problem over, it was decided to inject naphtha into the air line but we were unable to obtain any, so used aviation gasoline. We installed a 4-quart tank on the main air line so that we could allow the gasoline to feed in slowly, using from 3 to 4 quarts per day, at the same time increasing the air to a maximum of 2 cubic feet per gallon. By the time the smudging was passed we had used a little more than 10 gallons of gasoline and our pressure was back to normal. Our plates were cleaned as when installed, and our problem had been solved.

Problem No. 3 came in the way one piece of equipment functioned. Our secondary clarifier always showed a slight disturbance at two different points in the tank, more noticeable when the flow was high than when normal. After studying the problem for some time, I concluded that if an additional baffle could be placed around the incoming flow in the center of the tank it would materially help. It was not possible to take the clarifier out of operation; so it was necessary to make the repairs while the flow was on. The flow in question entered the center baffle, which is 9 feet across, through a 12-inch pipe with a flared outlet about 3 feet across opening towards the top and surrounding the central shaft. It was supposed to check the flow so as to make the distribution even over the entire clarifier, but it was failing in its work. I constructed a baffle of 16-gauge galvanized iron that would set on top of the flared outlet and to extend within 3 inches of the surface of the water. In other words, a baffle within a baffle. Our clarifier now is without a current at any point and we are getting better settling of the activated sludge with the result of a clearer effluent. Problem No. 3 has been answered.

We have many other problems, some answered and some unanswered, but time will not permit me to discuss them at this time.

OPERATORS' PROBLEMS

By J. C. CLARK*

The following items are some of the causes of troubles experienced by us as operators.

One of our greatest sources of grief comes from the practice of casting conduit in concrete. It does preserve the conduit and help the looks of the plant, but the trouble occurs when the conduit becomes flooded and the wiring insulation breaks down and shorts occur. Usually the conduit is too small to take a heavily insulated wire to give good elec-

*Chief Operator, Huntington Beach, Calif.

trical protection, so you either have to use the same old type of wire or run new conduit.

In many plants the artistic side is stressed often at the expense of the operating efficiency. We operators appreciate beauty in plant design, but not at the expense of operation as faulty operation gives us all the grief.

Manufacturer's designs of equipment and engineers' ideas as to the application of equipment may not always work out to the operator's advantage. The operator, I think, should be given some consideration and his opinion asked at least on any new equipment.

Most of us in starting up a new plant do not have a sufficient budget allowance to care for needed changes and adjustments that may have been overlooked. I believe all new plants are likely to have some necessary changes during the tuning up period. If we are consulted first, it may be possible that some of these changes can be made on the plans and not after the plant is built and some money thereby saved.

It would also be a big help to us if we were given a set of rules to go by. The designer has his books, but we have little except the knowledge gained by experience. Such a set of rules would be very valuable to turn to in case of trouble, of which we get plenty.

I hope that with the experience of these contacts and meetings with the designers and manufacturers that we will be able to express our ideas better and obtain help in solving our operating problems.

EXPERIENCES AS SUPERINTENDENT OF THE MEDFORD, OREGON, SEWAGE DISPOSAL PLANT

By JOHN A. CLARK*

To acquaint you with the situation at Medford, Oregon, I shall first give a brief history of the sewage disposal problem and a concise description of the plant. The present population of the community is estimated to be approximately 12,000. Most of this number live within the sewered area of the city. Medford is situated in the famed Rogue River valley of southern Oregon—and the community lies both on the east and west sides of Bear Creek, one of the main tributaries of the river. This creek has always been the site of disposal for the sewage of Medford. Prior to the construction of the new plant the city had a septic tank—so called—but which in reality acted only as a settling basin. In 1932 the firm of Greeley and Hansen was called in to make a preliminary report on the city's problem. Their report advised the city to construct an Imhoff tank and trickling filter type of sewage disposal plant. This plan called for a long outfall sewer in order to obtain the necessary head to operate such a plant without sewage pumping. Consequently, the estimated cost was quite high and in the midst of the depression and before the days of P.W.A. the people flatly refused to pass the necessary bond issue. In 1935

*Formerly Plant Superintendent, Medford, Oregon.

a few of the leading citizens of the community thought that it would be possible to pass a bond issue if the amount could be kept at a more psychological figure—less than $100,000. An activated sludge plant was designed, which would operate on a gravity basis on the site of the old septic tank which the city owned. The bond issue for this plan was passed and with the aid of the P.W.A. the plant was constructed and placed in operation in July 1936. The entire cost of the improvement was nearly $120,000, of which the city pays some $88,000. This is to be raised by deducting 15c per month from each water bill of $2.50 per consumer. The maintenance and operation costs are financed by direct taxation as a part of the Health budget for the city. The amount budgeted for the year January 1 to December 31, 1937, is approximately $14,000.

Medford is blessed with a marvellous water supply—both as to quality and quantity. The water comes from a large spring in the mountains some forty miles from the city, and it is unique, I believe, in that the water never "sees" light until it comes out of the consumer's faucet. Due to the ample supply, meters are not used except on the larger commercial connections. Hence the very large average per capita consumption of 350 gallons per day. This results in a large amount of weak sewage for the disposal plant to handle.

The plant was designed to handle a maximum rate of flow amounting to 3.6 m.g.d. and an average flow of 1.8 m.g.d. This disposal plant consists of the following units:

1. Manually cleaned bar screen—1-inch openings:
2. Grit chamber—the flow of which is regulated by a constant velocity weir—giving a velocity of 1 ft. per sec. The chamber is also manually cleaned at intervals of about three months.
3. Primary settling tank equipped with a Link Belt clarifier. Detention period for average flow is 45 minutes.
4. Aeration tank of the diffused air spiral flow type, using "Filtros" plates at the bottoms of the tanks. The detention period is six hours under average flow of 1.8 m.g.d. The air is supplied by one 1500 cu. ft. per minute and one 1000 cu. ft. per minute Root-Connersville positive displacement blowers.
5. Final settling tank—50 feet in diameter—equipped with a Dorr Sifeed Clarifier. Detention period for average flow is two hours.
6. Separate Sludge Digestor — using the Pacific Flush Tank Co. Downes Floating roof. The gas is run through a Pacific Flush Tank Co. type A flame trap and pressure regulator. The larger portion of the gas is turned in an American Radiator and Standard Sanitary Co. Ideal Gas Boiler—the hot water produced is circulated through a large coil in the digestor—and the remainder of the gas is burned in the excess or waste gas burner.

The problems which we have had at this new plant could probably be described no better than by a repetition of Mr. Carl Tennant's

excellent paper, which he presented at the last spring conference of the California Sewage Works Association held in Stockton, California. Nevertheless, I do wish to speak of two problems which I consider to be quite unusual.

The chief industry of Medford, Oregon, is the packing and shipping of pears. All of the pears have been sprayed with lead arsenate, which according to federal regulations must be removed prior to packing. The poisonous material can best be removed by washing the fruit in a weak solution of hydrochloric acid. This process is carried out in large machines. In the ten packing plants some 300,000 gallons of water are used daily. Most of this is carried away in the city sewers. The resultant sewage is very acid. In fact, during the 1936 season the sewage ran, upon several analyses, as high as 120 to 150 parts per million total acidity expressed in terms of calcium carbonate. It was estimated at that time, that it would require 900 pounds per day of hydrated lime to neutralize the sewage, at a cost of $18.00—or about $6.00 to $7.00 per million gallons for chemicals. During the present season many of the packing plants are experimenting and endeavoring to neutralize their wastes by passing the solution through large well baffled redwood boxes containing a few tons of crushed limestone. Some of the plants have carried this waste to a separate storm drain. As the present packing season began after I left Medford, I am unable to report upon the success or failure of these procedures. However, I am confident that the next month will be a very difficult period for the operators.

The second problem upon which I wish to report is in relation to the proper lubrication of equipment. As you all know, any lubrication system must be as nearly failure proof as possible, especially if the plant is to be left unattended. The Root-Connersville blowers which Medford has are lubricated by a force feed circulating system. The oil pump is actuated or propelled by a direct shaft connection. After a short shut down of the blowers last winter, it was thought advisable to use the small blower—and upon starting the machinery it was noticed that the oil was not flowing in the sight cups. I immediately shut off the power. Upon investigation we found the flexible coupling in the oil pump shaft completely ruined and also found the shaft "frozen" in the casing. In other words, the steel shaft was welded to the cast-iron casing—this was due primarily to the lack of a proper bronze bearing. It was necessary to drill and collapse the shaft to remove it and then to machine a new shaft and also install a bronze bushing in the casing. The main problem was then to protect the machines, each of which has six large bearings, from any future lubrication failures. At first my study was in the nature of a "Rube Goldberg gadget" invention. However, after conferences with some of the electricians from the power company we installed a "Penn Co." pressure switch of the low-pressure type on each machine, which now control the holding coil circuits of the starting compensators. The switches close at an oil pressure of five pounds per square inch and

open or break the circuits when for any reason the oil pressure in the circulating feed lines is less than three pounds.

We have considered this an excellent insurance policy for a cost of only $50 for the two machines. Such protections and precautions will save the city a great deal of money and the superintendent much anxiety, for now the plant may be safely left unattended.

PROBLEMS OF THE ENGINEER

By HAROLD F. GRAY*

These discussions of operators' problems are always exceptionally valuable to the designing engineer, and bring out important points which ought to be considered in design. However, some of the deficiencies in plants brought out by Mr. West and others are not chargeable to the engineers. They are at times confronted with conditions over which they have but little control. For example, they may be asked to design a sewage treatment plant within the limits of funds available for construction which may be insufficient for the purpose. Naturally, they cannot produce a completely satisfactory plant under such conditions.

It is difficult to convince a non-technical city council of the advisability of a very flexible design which can meet wide fluctuation in both characteristics and quantities of a highly variable raw material such as sewage. It seems even more difficult to convince them of the necessity of providing for the comfort and convenience of the operator. And the idea of architectural embellishment and landscape gardening for sewage treatment plants apparently is almost incomprehensible, at least on the Pacific Coast.

With increasing use of mechanisms in sewage treatment plants, we find that the operators' troubles are in increasing degree due to mechanical breakdowns and inadequacies. At one plant the operator told me he had counted some 8,000 mechanical breakages in the space of a few years. There is apparently room for improvement in the design of mechanical equipment.

At least some operating experience ought to be part of the equipment of the designing engineer, and I would urge that as frequently as possible our young engineering graduates be employed as operators of sewage treatment plants. Their great interest in the work, enthusiasm and energy, plus their basic and specific training, should result in better plant operation. True, they would not remain long as operators, but there is a new crop of graduates each year, seeking experience. Their employment will be good for the plant and for the men, both in large plants and in small plants.

*Consulting Sanitary Engineer, Berkeley, Calif.

A CLEAN PLANT WITH A GOOD OPERATOR HAS FEW PROBLEMS

By F. S. CURRIE*

To my mind, the largest single problem in the operation of a sewage treatment plant is the operator. No matter how well a plant may be designed and constructed, a poor operator can ruin it, and no matter how poorly a plant may be designed and constructed, a good operator can at least give it the outward appearance of a good plant.

Excepting the water department, a sewage treatment plant represents a city's largest single investment, yet in many instances the requirements for the position of operator are based more on political affiliation than ability.

After following the operations of various sewage treatment plants in Southern California, the following is my idea of the ideal plant operator:

First: He should be alert and energetic. There is no job that I know of where a man can become lazier easier than operating a plant. That he is alert and energetic assumes that he will take an interest and pride in the operation of a plant. I have yet to see an ambitious man take over the operation of a plant who did not in a very short time develop an intense pride in his work, even though at the start he might have considered the job beneath him.

Second: A plant operator should be naturally neat and clean. This applies to his personal appearance as well as the plant itself. If he is not personally neat and clean, he certainly will not be neat in the care of the plant.

Third: He should have a real liking for machinery and possess some mechanical ability.

Fourth, and least: He should be able to make such tests and keep such records of the plant operation as will allow him to better the operation of the plant in the future and show the costs and results of said operation. However, I would rather have a clean well operated plant without records and tests than a dirty poorly operated plant with all the records in the world.

Here in Southern California there are some twenty sewage treatment plants in operation which we have designed. Believe it or not, of this number there are only five around which any trees or shrubbery have been planted. At only two of these plants has there been any attempt to set out a lawn. Of this number I can name four plants over five years old on which not a nickle's worth of paint has even been used. On one of these plants the arms of the rotary distributor are nearly eaten through with rust. I do not believe the nozzles have been cleaned on the average of once a year. This neglect will shortly cause the ex-

*Consulting Sanitary Engineer, San Bernardino, Calif.

penditures of more than one thousand dollars. Five dollars worth of paint and two days of the operator's time would have prevented this. I can name on the fingers of one hand the plants where the pumps and other operating machinery are **properly** greased and cared for. It is a crime the way oil and grease are allowed to drip over the equipment and floor without any attempt toward wiping it up.

How many plants have any of you been in where the sink and drain board are clean, where the chemical equipment is cleaned after tests, where the bowls on the chlorinators have been cleaned within the past year, or where the floors have been scrubbed? We have plants with white tile floors that would look better and cleaner if they had been plain concrete.

As to neatness around the plant, I recall one plant where lime and alum are used as a coagulant. There are full and empty sacks lying all around the control room. Around the dry feeder it looks like snow had fallen. In some plants tools and equipment are seldom, if ever, put away. If you would stop at a gasoline service station and find a toilet and sink as dirty as those in the average sewage treatment plant, you would report it to the management.

I can show you light globes in plants that are so dirty that it is hardly possible to tell whether they are on or off.

The day of building a sewage treatment plant in the city dump and treating the plant like part of the dump is over. More and more attention is being paid to the architecture and the general appearance of the plant itself. The cost of planting and maintaining trees, shrubbery and lawns around a plant is negligible, especially when you consider that water and fertilizer are free. There is nothing that will go farther toward the elimination or at least the diffusion of odors than trees.

The average plant operator may feel that the landscaping of a plant is not part of his duty and that it, together with the painting of buildings and equipment, cannot be done because the City Council will not furnish the funds. But a good plant operator can obtain these things if he has the initiative to go after them. Nine times out of ten it is the operator's fault if these things are not done.

The full time operator of a sewage treatment plant of less than a million gallon capacity that doesn't have enough time on his hands to keep a plant neat and clean, to set out and look after flowers, shrubbery and lawns is either inefficient or lazy.

A part of the standard equipment of every sewage treatment plant should be a gallon of each kind of paint used on the original construction, and an operator should never allow rust to appear on any iron work or let any woodwork go unpainted.

This association has discussed and sponsored a school for plant operators and I believe it is a fine thing, but the most important part of plant operation is not B.O.D.'s and D.O.'s but neatness, cleanliness and care of equipment. No one of us ever saw a clean, well kept, neat appearing plant that wasn't well operated, and producing good results.

VENTILATION ELIMINATES EXPLOSION HAZARD

By ADOLF H. KOEBIG, JR.*

As most of the engineers will undoubtedly discuss the matter of remedying foaming in tanks and bulking of sludge, it occurred to me that discussing the matter of odor control in and around the plant would be worth while.

Over a long period of years we have observed that in many instances where plants were located along the sea-shore or where the air was heavy in the morning, the escaping gases lay low, not alone in the buildings, but also immediately adjacent thereto, which brings about a very dangerous condition, especially in the pump wells and the buildings over said plants.

We have found this situation can be satisfactorily and economically remedied by the installation of electric driven fans with sufficient capacity and with vent ducts leading from the wet well, pump pit and other structures housed in buildings to the top of the building so controlled and operated that when the pumping equipment was in operation or when the door of the building was open the motor driving the electric fan would automatically start in operation and clear the different structures of the dangerous condition resulting from collection of gases. In this way the possibility of explosions was eliminated as well as making conditions more favorable for the operation of the plant.

It was found that a ¼-H. P. motor would, under most conditions be sufficient to create enough air capacity for the ordinary plant and the period of operation is so nominal that if operated as described above the cost is not a great increase to the operating cost of the plant.

*Consulting Sanitary Engineer, Los Angeles, Calif.

PROBLEMS IN PUTTING THE MARINA PUMPING PLANT IN OPERATION

By BEN BENAS*

The Marina Sewage Pumping Plant went into operation in April of this year. This plant pumps the sewage of the Marina District which discharged previously at the shore thereby poluting the Yacht Harbor and neighboring beaches to a point approximately two miles distant where the main flow from the easterly part of the City now discharges.

The tributary district to the plant comprises approximately 1000 acres and has a present population of 65,000 and an ultimate population of 100,000. The plant is designed to take care of the sanitary flow plus the runoff from light summer rains giving an average ultimate sanitary flow 10 MGD with a peak storm flow of 26 MGD.

The station is a 55-ft. internal diameter structure built completely underground. A partition wall divides the structure into two parts, the wet well and the dry well. Each part has separate stairway entrances from the surface.

The station provides in the main for the following features:

1. Control of the incoming flows by a float controlled hydraulically operated basin level regulator which prevents the level in the sump from using above a set elevation.

2. Emergency float controlled hydraulically operated shut off valves on the inlet and discharge lines operated from an independent water supply system.

3. 1—10-in. Pump capacity 2300 GPM against 35-ft. head single speed 890 RPM to take care of low flow.
 3—10-in. Pumps capacity 4000 GPM—75-ft. head two speeds 595-890 RPM.
 1—10-in. Pump capacity 4000 GPM—75-ft. head single speed 890 RPM.

The pumps are horizontal split case with closed impellors. The operation of the pumps are controlled by a float switch which cuts the pumps in and out at set elevations.

4. A surge tank directly connected to the discharge header.

5. A sewage type venturi located in a separate vault outside of the station with the register, settling chamber located in the station.

6. An independent water supply system to provide water for water seals for the pumps to prevent any cross connection to the City supply.

7. Venting of the sump through a 60-ft. high shallow stainless steel flagpole, 6-in. tapering at the top, and venting of the dry well through a duct which discharges at the ground surface.

8. A telemeter device which transmits the record of level in sump over the telephone lines to a fire station, the operator of which in case the alarm rings shows too high a level gets in touch with the super-

*Sanitary Engineering Designer, San Francisco, Calif.

intendent of pumping plants and transmits a crew to shut off the flow to the plant.

9. Main switchboard with recording ammeters, time meters, switches, etc.

10. Toilet, storeroom with work bench.

The station was designed to be fully automatic, however, during the first months of operation and probably during the life of the station an operator will be on hand during the day shift.

Every effort was made in the design to lay the units out to provide for easy access for cleaning and repairing. 1. The large valves and pumps were provided with hand hole plates. 2. U-bolts were set in the concrete at points to facilitate rigging for the movement of the machinery. 3. Removable concrete slabs were set in the roof over the valve pit and over the control room.

The plant as a whole has operated as expected. There are a few points which require mention.

A horizontal bar rack was located in the drop down division structure to prevent bricks, sticks and other large particles from getting into the control valves and the pumps. This rack was built of a number of removable sections set on cross members with openings parallel to the flow. Two spacings were used one 3¾-in. and the other 1⅞-in. in order to try which served the purpose best. The larger spacing allowed long pieces of timber, brick, etc., to get into the sump while the smaller clogged rapidly. A grating bar rack will be shortly installed with longitudinal and cross bars with 3¾-in. openings as an experiment.

No trouble has been encountered in the operation of the control valves except that at times one will not seat absolutely tight due to rags or other obstructions getting on the seat. This can be removed by working the valve up and down a few times. During the time the plant is not in regular operation, the small pump operating periodically has taken care of the leakage.

The cleaning of the sump has presented quite a problem. Previous to the operation of the plant, the sewer system was affected by the backing of the tide which caused considerable deposits of sludge. These deposits now discharge into the sump which has to be cleaned periodically. There are a number of hose connections provided for flushing, but the material gets too tightly packed to be loosened materially by this method so that the plant is shut down and hand cleaned, the material being removed by buckets to the surface.

The sewer system has been cleaned recently so that it is expected that these conditions will improve. If not, some method of agitation to prevent deposits will have to be installed.

There has been no trouble with the pumps. A few times it has been necessary to remove particles which can be done through the hand hole plates.

The surge tank has operated satisfactorily. It is necessary to drain

the tank to the sump periodically and to blow off the accumulation of gas. At present this discharges into the machine room, but a connection is to be made to the discharge duct of the venting system.

The venting of the sump is not adequate at all times, as the capacity was limited by the size of the flagpole. It may be necessary, in the future, to provide for additional duct discharge into the sewer. A considerable reduction of the amount of gas liberated in the sump can be obtained by keeping the level about two-thirds up on the inlet pipe, thereby reducing turbulence.

The sewage venturi has operated satisfactorily, it being only necessary to drain and vent the interconnecting piping at least once a week.

No trouble has been experienced with the telemetry system.

A Pemberthy ejector installed in the pump room is to be replaced with a small sewage sump pump. This pump could not handle the sand and grit resulting from the draining of the venturi vault and the settling chambers for the venturi.

The electrical work has functioned satisfactorily except that trouble has been experienced with obtaining a satisfactory record with the recording ammeters. This is due to the fact that with across the line starters, the starting current causes the recording pen to strike the stop with too great a force, thereby throwing the ink out of the pen and affecting the accuracy of the instrument. An attempt to use oil of greater viscosity was made but this was not satisfactory. At present smoke charts are used, eliminating the use of ink, but this does not affect the movement of the pen. Rubber is being used to prevent damage to the pen.

THE RAG AND GREASE PROBLEM AT THE CITY OF LOS ANGELES' TERMINAL ISLAND TREATMENT PLANT

By H. G. SMITH*

While the usual number of "bugs" encountered in starting up a new treatment plant made their appearance in due time at Terminal Island, undoubtedly the most trying on the mental and physical condition of all concerned, have been rags and grease.

All sewage received at this plant now arrives by way of two force mains and makes its first appearance when entering the siphon feed clarifier. These force mains are fed by four separate pumping plants, in turn receiving the sewage from the San Pedro, Wilmington, and Terminal Island areas, a total of some three and a quarter million gallons per day, averaging over 400 parts per million suspended solids.

Each of these pumping plants is equipped with bar screens having 2½ or 3 inch clear openings and as available money for construction was somewhat limited and the installation of a bar screen under such

*Division Engineer, Bureau of Engineering, City of Los Angeles.

conditions relatively costly, it was decided to eliminate this usual adjunct and install a type of sludge pump capable of handling and grinding such rags as might escape the bars at the pumping plants.

From the standpoint of expecting that the rags escaping the plants would be only the smaller and less troublesome ones, this proved to be a mistake. Aside from suits of underwear, legs of overalls, socks and ladies' wearing apparel which managed now and then to dodge the bars and pass through the pumps, the smaller strips wound themselves into balls and after collecting hair and other debris finally presented themselves at the suction end of the sludge pumps.

These pumps with 4-inch suctions and rated capacities of 50 g.p.m. and powered by 2 ½-H.P. vari-speed motors, according to the manufacturers, were ready to take anything that came their way in the textile line, first grinding it up before passing it on to the impellers. While this type and size of pump had apparently functioned perfectly on underwear of genteel inland towns, they had never been up against such he-man stuff as the Port of San Pedro discards. At any rate they balked in spite of all the efforts and gentle words of the operators, so the manufacturer's agent was called in and given a working demonstration. This resulted in a visit by the manufacturer's Chief Engineer, who, after quite an extended study of the particular conditions, went back to his factory and arranged the fabrication of an entire new unit. This on being installed has proven very satisfactory, and while it may grunt now and then over some extended wardrobe, it soon chews it up and carries on. The pump company is now about to install a second and similar unit which in connection with a plunger pump used for recirculation, standby and plugged lines, a high pressure water type pump for wash water and also plugged lines, together with a sewage trash pump handling the sump and a Jaeger portable for miscellaneous use, go to make up what has proven to be a very serviceable combination.

However, as all of these pumps decline beer cans and two by fours, which are becoming all too frequent, a trash rack is being constructed in the final contract for the completion of the treatment plant, which it is believed will be beneficial to the operation of the pumps as well as the mental condition of the operators.

While the San Pedro area holds the palm for rags, the Wilmington area contributes by far the larger portion of the grease and oil. The bulk of this grease originates at several fish canneries, and at times has covered the surface of the 80-foot clarifier with from two to four inches of glutinous matter for several hours at a time in spite of all efforts of the different types of skimmers so far installed.

Although it is the policy of the Bureau to handle all trade wastes entering the sewer up to a reasonable amount, efforts, partially successful have been made to have these industries treat and recover this waste at their plants. By installing certain equipment one of these concerns has cut the suspended solids from 39,000 to 2,830 p.p.m., and the oil from 7,940 to 1,710 p.p.m.

An ordinance was also adopted by the City Council restricting oil or grease entering the sewer to 600 p.p.m. and suspended solids to 1000 p.p.m., but it has been difficult to enforce. When considerable pressure has been brought to bear by the City, the industries have turned the waste into the harbor, whereupon after a time certain shipping interests have "turned the heat on", and threatened damage suits, with the results that the wastes go back into the sewer again.

In the original clarifier installation, the ordinary bar type of skimmer was used. As this proved inadequate the Dorr Company furnished a new type of skimming equipment consisting of a floating cylinder approximately 8 inches in diameter and 9 feet long. Attached to the rake arms this moves, always in a radial position around the outer surface of the tank collecting the grease and pushing it on ahead. Beneath the steel bridge of the clarifier a metal trough is installed, the lip of one side being just at the surface of the liquid. In operation, as the floating cylinder pushing the mass of grease ahead, approaches within a few feet of the trough, it trips a lever and by means of interconnecting mechanism causes the lip, which is hinged to the trough to dip below the surface a sufficient depth to allow the collected grease to flow into the trough from which it is discharged by gravity to the outlet pipe. As the floating cylinder actually reaches the trough the mechanism returns the lip to its original position while the cylinder ducks beneath the trough to bob up on the opposite side and continue again around the tank.

This device will operate at a plant receiving a normal amount of grease with very little attention, and is undoubtedly an improvement on the old bar skimmer. However, with the great quantities of oil and grease received at Terminal Island, particularly during the sardine season this equipment becomes "snowed under" and a new paddle type of skimmer devised by our Chief Operator, Mr. Fiscus, is being installed.

The floating cylinder will still be used for collecting the grease but in place of the trough will push the floating matter against a fixed baffle where a series of paddles suspended from endless chains running on sprockets and operating adjacent and parallel to this baffle, will draw the grease to and up a ramp ending at the outlet pipe.

Until quite recently this grease was discharged onto sand beds, permitted to dry and finally burned in a temporary furnace using a portion of the surplus gas from the digester, amounting to some 80 to 90 thousand cubic feet per day, to assist in the incineration. This proved very cumbersome and laborious and the method has been superseded by flowing all grease to the sump and pumping it into the digester. Thus far there does not seem to be any serious resentment on the part of that unit.

The final contract for the sludge beds, incinerator, bar screens, drives, walks and parking of the grounds, is now under way, and it is believed that these vexatious problems above enumerated, have been or are about to be solved.

SUPERNATANT LIQUOR

By EARL M. KELLY, Engineer
The Dorr Company, Inc.

NOTE: This paper was published in full in the Sewage Works Journal, Vol. 9, Page 1038. The following abstract indicates the contents of the paper.

Starting with a review of the characteristics of supernatant liquor from sludge digesters, both as to suspended solids and B.O.D. requirements, the paper takes up a detailed treatment of the handling of this liquor. It is pointed out that where the supernatant is returned to the influent of the plant any material amount of suspended solids may have a serious effect. It is possible that the liquor may contain solids of septic character which are non-settling, and this tends to disturb the action in the clarifier, with the result that a considerable portion of these solids may leave with the clarifier effluent, and thus remain in circulation.

The paper then reviews in considerable detail the process known as the Multidigestion System, which is in operation in more than 30 representative plants, and is considered to have distinct advantages over the older form of single stage or series digesters. This system, which may be inspected at Santa Clara and San Mateo, consists of digesting sewage sludge in two steps. In the first, or Primary Digester, special agitators of the Turbo-Mixer type are provided, and uniform temperature control is maintained. Under these conditions, raw sludge is seeded immediately upon entering the digester, and is heated to an optimum temperature, accelerating the normal digestion processes. Usually more than 90% of the total gas produced is generated in this primary unit.

The Secondary Digester is a plain, unheated tank provided with a special steel gas holder cover. This tank is designed with size sufficient to provide for storage during sludge thickening, sedimentation of supernatant, and sludge disposal requirements of the plant. In the secondary tank, the sludge concentrates rapidly to 90-95% moisture, and the supernatant liquor is much clearer than would be obtained from single stage digestion.

The gas holder cover over the secondary digester stores gas produced from both digesters.

The paper concludes with data indicating the results of the Multidigestion System.

OPERATING PROBLEMS

By L. H. CHAMBERLAIN*

The following are a few of the sewage equipment problems that have presented themselves in Southern California during the last few years.

Metering the Flow of Sewage

A rather unique sewage metering application was introduced recently when apparatus was developed to measure with one recording and integrating meter the total flow of sewage passing through two separate Parshall Flumes. If the entrance head on a Parshall Flume varied in direct proportion to the flow of sewage the problem would have been a relatively simple one. However, this relationship is not direct, so it was decided to translate the motion of each of the two floats to a new motion directly proportional to flow. This translation was accomplished by means of two cams arranged so that a single movement was obtained that varied in direct proportion to the total flow passing through the two Parshall Flumes. From this point on, the operation of the meter was made the same as though it were operated by but one Parshall Flume.

Trickling Filters and Rotary Distributors

A problem of interest to the sewage disposal plant operator has to do with the uniform distribution of sewage over a trickling filter by means of a rotary distributor. If nozzles are provided having the proper relative capacity when the arms are stationary, the distribution will be upset when the arms rotate due to the effect of centrifugal force. This problem has been solved by holding rigidly to a definite standard center post design, which makes it possible to accurately predetermine the speed of rotation. Knowing the speed of rotation, the nozzle sizes are made to provide uniform distribution at average speed. The fact that nozzle capacities are radically increased by the effect of centrifugal force is shown by the following tabulation which lists the increase in head in feet of water at various radii due to the centrifugal force produced by a speed of one revolution per minute:

Radius in Feet	Increase in Head in Feet of Water
10	.02
20	.07
30	.15
40	.28
50	.42
60	.60
70	.83

Where rotary distributors have been installed beneath roofs, it has been possible to materially lessen the cost of the combined structure by

*District Manager, Water Works Supply Company.

utilizing the rotary distributor center post for the center roof support. This arrangement has introduced the problem of how to prevent the deflection of the center post by expansion or contraction of roof members, or by settlement of the peripheral roof supports. This problem has been solved by transmitting the center roof load to the top of the center post through a hardened steel ball which bears, top and bottom, against hardened steel plates to give complete freedom of action.

Primary Clarifiers:

In connection with the operation of primary clarifiers there are night periods when the volume of sludge deposited does not warrant the continuous operation of the raking mechanism. In several instances automatic periodic operation has been arranged by the use of an electrical time switch with a twenty four hour dial into which pins are inserted that start and stop the mechanism as desired.

Lubrication:

The lubrication of sewage disposal equipment is an operating problem worthy of the utmost consideration. In this particular field proper lubrication serves a dual purpose. Primarily it of course reduces friction and wear but it is of equal importance as a protection against corrosion of bearings which become ineffective and soon fail after the highly polished surfaces have been attacked by sewage gases.

DISCUSSION OF OPERATING PROBLEMS

The preceeding group of papers by Operators, Engineers and Equipment-men created considerable interest.

Mr. Albert Castro answered Messrs. F. S. Currie, E. A. Reinke and J. C. Clark, who asked questions on foaming, crops and B. T. U. value of digestion gas, respectively, as follows:

We have had no experience with foaming in sedimentation tanks in the cannery season. Such crops as sugar beets, lima beans and seed crops in general are grown on the lands irrigated with the plant effluent. The heat value of the gas from the digestion tanks is 500 B. T. U. per cubic foot.

Mr. Fred West did not present a prepared paper, but extemporaneously told of some of the difficulties experienced in placing the new Stockton plants in operation, prefacing his remarks with the statements "Ads do not tell the truth,"—"Everything but what I expected I got." The 3-in. bar rack openings, he said, are too large and pass too many of the neighbors cats and objects interfering with pump operation—2-in. or smaller openings would have served better. Until a cover was provided for the grinder hopper a rubber coat and hat was necessary equipment to avoid a free bath. The addition of a 2-in. water jet to the hopper proved a labor saver in feeding screenings to the grinder. "The Grinder—that's a good one." The grinders do not grind rags—we take them out of the sludge pumps every time they

turn over. A 24-in. snake went through the grinder and lost only two inches of his tail. During tomato canning season, the grinders handle 200 cu. ft. of tomato refuse a day. Screenings amounts to 250-300 cu. ft. per day. It has proven a continuous round to help things over, much of which might have been avoided by providing a test run for all new equipment.

Mr. J. C. Clark, in discussion, added the following: Mechanical equipment needs adjustment, it has been necessary at the Huntington Beach plant for me to balance the arms of the filter distributor. After taking the dosing equipment apart 19 times, the syphon was made to work satisfactorily by arranging for extra air space.

Mr. J. H. Van Norman chose to speak extemporaneously of his operating difficulties. Dampness and corrosion, he said, cause large maintenance costs. Wetness due to washing down the plant and condensation has given considerable conduit trouble. Fortunately, the conduits are of sufficient size to permit the use of lead doubles. In the future, however, conduits will be put in the open above the floor. The regulation of temperature at 70 deg. F. and air conditioning of the control room will do much toward reducing corrosion.

A single outside chain on the screenings elevator eliminates the clogging of the chain with rags, and the destruction of buckets when one of the two chains breaks.

Mr. A. M. Rawn expressed his regret that Mr. Carl Tennant could not attend the meeting and describe personally two contrivances of his design. The first, an air release on the effluent line consisting of an elongated pipe with a float and ball bearing which was devised after commercial valves failed. The second, a perfected skimming pan for grease removal and a rubber tired barrow to haul the skimmings.

Mr. C. C. Kennedy, in his extemporaneous remarks, said the designing engineer must be conservative but still try new things, and must be mindful of the money needed for the original plant and operation. Sewage plants of today are mechanical and the designing engineer cannot be responsible for foreign contents of the sewage that interferes with their proper functioning.

ELECTRICITY FOR SEWAGE WORK OPERATORS

By GEORGE A. WEBER*

When I accepted your very kind invitation to speak to you on the subject of "Electricity for the Sewage Disposal Plant Operator" I did so with the distinct understanding that those of you, who perhaps have forgotten more about electricity than I ever knew, would have the privilege of "walking out on me" and, to those who probably are interested, I hope to be able to impart at least one constructive idea without offering any affront to your intelligence.

The operators with whom I have had the pleasure of associating,

*Electrician, Palo Alto, Calif.

have been thoroughly educated along the lines of chemistry and bacteriology, and the subject of electricity had been given only a cursory consideration, (if any) with the result that when they are placed in some disposal plant, entirely electrically operated and with some of the latest electro-automatic devices therein installed, naturally they are somewhat at a loss as to what it is all about. This talk however, is not for the purpose of pouring several gallons of kilowatts into your ears, thereby making of you full fledged E. E.'s, but rather to give a few fundamental ideas relative to the subject.

Let us first consider the subject of fuses:—The fuses are installed in the electric circuit for exactly the same purpose that a safety valve is put on a steam boiler, viz.:—to limit the amount of pressure which the boiler may be subjected to or, in the electric case, to limit the amount of current (amperes) which can flow through that particular circuit. Therefore, it follows that should a fuse "blow" in any of your electrical circuits, NEVER replace it with a fuse of a higher ampere rating than the one just blown, as you may be endangering your motors or other equipment, just as you would endanger the boiler by hanging a heavy weight on the safety valve. In other words, always consider your fuses a safety valve on the motors, etc. Should your replacement fuse also blow out, you may be sure that there is something wrong, causing an overload, and the best procedure is to call for your electrician or mechanic in case the overload happens to be caused by tight bearings or by something that is caught in the impeller of the pump.

And while we are on the subject of fuses, let me admonish you to use care in the changing of fuses. Either equip yourself with a suitable pair of insulated fuse pliers or, if you change fuses with your bare hands, BE VERY SURE that you are thoroughly insulated from the ground, that you are NOT standing directly on a moist cement floor, or that you are not in contact with any pipes of any description while you are in contact with any part of the equipment that MAY be "alive." It is a very good axiom to work as Dr. Steinmetz once instructed the electrician to work:—"Work with one hand in your pocket." In other words, DO NOT furnish a path directly across or through your body.

Some of your equipment may be protected with what is known as an "Over-current" device. This is merely a heating coil, placed in two of the three wires of a three-phase line, which coil heats up in direct proportion to the amount of amperage flowing in the line. When the amount of current becomes excessive, the heat too becomes excessive. This expands the holding device to a point where it fails to keep the circuit intact. The repeated opening of the circuit due to these coils operating, indicates trouble in precisely the same manner as does the blowing out of a fuse and your electrician should be called to repair the fault or remove the cause.

Beside the overcurrent coils there is, in practically all power motor circuits, a coil so situated that the closed position of the switch de-

pends on this coil being energized, thus holding the switch. This is called a "no voltage release coil" and depends on the continuity of the line voltage to keep it operative. In case of failure of the line voltage, this coil becomes de-energized and allows the switch to fall open, severing the motor from electrical connection with the line. The main object of this disconnection of the motor from the line in case of line failure, is to prevent a disastrous and excessive rush of current into the motor while it is standing still and connected to a load. The excessive current, which would rush into the windings of the motor under these conditions, would most probably "puncture" the insulation of the wires comprising the winding, and cause the motor to "burn out."

Going back now to the over-current device:—The overcurrent coils hold a circuit closed, which circuit is directly connected with the "no voltage" holding coil just mentioned, and any opening of the holding coil circuit by the operation of the over-current coils has the same effect upon this holding or "no voltage" coil as would a complete failure of the line voltage. In either event then, the motor is disconnected from the line until such time as the proper steps are taken to rectify that which has "gone wrong."

It follows then, that any device or sticks used to KEEP these coils from disconnecting the motor from the line, are used at the risk of severely damaging your motors and are in the same category with a piece of haybale wire with which the safety valve of a boiler is tied down; to thus "haywire" your protective equipment is to invite destruction of your equipment and is very bad practice to say the least.

Lastly, let me repeat:—ALWAYS PLAY SAFE! The fellow who "is not afraid of the stuff" is either just plain foolish, or is trying to be "smart" and put up a brazen front. NEVER smile at the fellow who confesses that he IS afraid of it. The lad who "eats it for breakfast" is the one YOU will be reading about in the papers some day. Electricity is the original "hit 'em first and talk to 'em afterwards" person. If I may be so bold as to speak for myself—I have had volts and amperes fed to me in my bottle when I was a kid—I was raised alongside of a cribful of kilowatts and believe me to be very sincere when I say in closing that

I ALWAYS HAVE BEEN AND I ALWAYS WILL BE DEATHLY AFRAID OF ELECTRICITY!!

BACTERIOLOGY IN RELATION TO SEWAGE DISPOSAL

By RAY L. DERBY*

The microscopic organisms present in sewage may be roughly classified as plankton which includes algae, protozoans, rotifers, crustacea, the higher bacteria, etc., and the bacteria proper. This paper will deal principally with the latter, but the higher bacteria will be briefly touched on since at times they are of very great importance in the disposal or treatment of sewage.

Bacteria are minute microscopic single celled plants, lacking in the chlorophyl or green coloring matter of true plants. They multiply by fission or division of the cell about once every twenty minutes under normal conditions. Being but single celled organisms, they normally obtain their food by absorbing solutions through their cell walls. They must, therefore, not only live in a liquid or semi liquid medium but must be able to break down or liquify solid substances in order to absorb their food material through their cell walls. In order to do this they secrete enzymes which liquify and partially digest their food material outside the cell wall before it is absorbed and finally digested within the cell. In many cases these enzymes or the by-products of cell metabolism are quite virulent poisons as in the case of Botulinus and Tetanus. Here these by-products or enzymes alone will cause the diseases of meat poisoning and lockjaw respectively.

Bacteria may be classified in many ways depending on form, manner of living, effect on other animals or plants, etc. In regard to form there are three general groups. They may be classed as bacilli or rod shaped, such as E. coli, E. typhii, etc. They may be round or grape shaped and are then known as cocci, of which the staphylococci and streptococci are well known in sewage flora, or they may be curved or corkscrew type known as vibrio or spirilla of which Asiatic cholera is best known. In regard to form, they may also be classed as spore formers and non-spore formers. Spores are a sort of seed or highly resistant form certain bacilli may take when an environment is particularly unfavorable to them. In this form they may withstand drying or boiling for long periods before being finally killed.

Bacteria may be saprophytes or parasites, depending on whether they live on the substance of dead or living bodies. They may also be classed as pathogenic or non-pathogenic, depending whether they are capable of producing disease in other plants and animals. All pathogenic bacteria are parasites, but parasitic bacteria are not necessarily pathogenic. Obligate parasites are those species capable of living only upon animate matter. Facultative parasites may exist upon either dead or living matter.

There is also the classificatoin of aerobic and anaerobic bacteria or those able to exist in the presence of atmospheric oxygen and those un-

*Assistant Sanitary Engineer, Bureau of Water Works and Supply, Los Angeles.

able to live in its presence. We further have obligate anaerobes and facultative anaerobes.

Of interest in late years to sewage treatment plant operators, have been the thermophilic bacteria or those organisms thriving best at higher temperatures than body heat. All bacteria are very sensitive to temperature. At 0° C. practically all bacterial activity ceases though death does not always result unless the low temperature is of long duration and even then spores may be but little affected.

The thermal death point or temperature that will kill at ten minutes exposure, varies but is about 60° C. for the vegetative forms (not spores) of many species. Spores will require a much higher temperature, some being resistant to boiling for an hour or more. Sterilization in the autoclave with a steam pressure of 15 lb. or 120° C. for 20 minutes or dry oven heat of 170° C. for an hour is usually effective and complete. Certain types of bacteria, however, will normally live and thrive better at a higher temperature than 20° C. to 40° C. These are often found around hot springs.

Since bacteria are microscopic in size they are very difficult to see and count or otherwise identify, even with a microscope. The use of solid media is the most satisfactory method for their culture. A petri dish or flat dish about 1 cm. deep and 10 cm. in diameter is used. A media consisting of agar or gelatin and containing the desired nutritive material is placed in the dish mixed with 1 cc. of water or sewage. In the latter case a high dilution of the sample is used. The plate is then incubated for 24 hours at 37° C. for agar and 48 to 72 hours at 20° C. for gelatin. At the end of this time, each organism will have grown to a colony visible to the naked eye. These colonies may then be counted and individual colonies examined under a microscope by staining a smear from the colony.

The number of total bacteria present in sewage varies with the type of sewage, time of year and hour of day, age of sewage and temperature at which the culture plate is incubated. A count on gelatin at 20° C. will range from 10 to 20 million per cubic centimeter, while agar at 37° C. will average between one to five million per cc. The lower agar count is probably due to the fact that the normal temperature of sewage is 16° C. to 20° C. and those species accustomed to a warmer temperature find the cooler water unfavorable for their development. Most bacteria living within the intestinal tract of warm blooded animals grow better at body temperature, 37° C., than at the ordinary room or water temperatures of 20° C. At the higher temperature colonies will develop more rapidly in 24 hours as against 48 hours for 20° C. Because of this and the fact that agar will not be subject to liquifying bacteria as is gelatin, the agar plate is now the more generally used.

There are some 60 to 70 species of bacteria normally found in sewage, of which less than 10 per cent are obligatory anaerobes, the remainder being facultative anaerobes or aerobes. Except in the case of the experimental station, or research plant, there is little need for isolating

or identifying the various species. For the operator of the small plant, the agar count is useful as a means of determining the efficacy of chlorination by taking a count before and after treatment.

Certain of the bacteria found in sewage are characteristic of it and may be fairly easily identified. Because of their constant presence in sewage, this group is used as a means of determining the possibility of the presence of sewage in an otherwise uncontaminated water. This group is known as the coli-aerogenes group and its characteristic reaction is the formation of acid and gas in lactose broth. The absolute identification of E. coli of sewage origin in water depends upon further reactions that are more or less time consuming, but tentative identification of the group by the foregoing reaction will show possibility of sewage contamination and give early warning.

E. coli, however, is a rather hardy organism and often will be found when the sewage pollution is quite remote and therefore not considered highly dangerous. For this reason some workers have advocated the use of the identification of sewage streptococci as a measure of sewage pollution. Streptococci, according to many bacteriologists, sometimes possesses a greater or a lesser longivity in water than E. coli and therefore is considered no more reliable as a measure of recent polution. Generally the E. coli appears the most sensitive.

Of the pathogenic bacteria present in sewage, typhoid, dysentery and cholera are of the greatest importance to man. The United States has not had an outbreak of Asiatic cholera since the turn of the last century and so this disease is given little consideration. Typhoid and dysentery continue, however, as a reflection on the imperfect methods of water and sewage treatment still in vogue in parts of the country.

Typhoid and dysentery bacilli, being parasites, will not exist for long outside of the body. Their length of life is dependent upon temperature, food supply and natural enemies present. In clear water and sunlight, their life will seldom excel a week or ten days, although longer periods have been recorded. However, in sewage three to four weeks is common and reports of as long as eight weeks have been recorded. Cold water is less favorable to their development than is hot water. The possibility of isolating and identifying E. typhi from water or sewage is rather uncertain. Even when typhi is known to have been present, there has often been a failure to recover it. In ordinary sewage, unless the proportion of typhoid patients or carriers contributory were large, the number of E. typhi present would be small as compared to E. coli and other organisms. For this reason the presence of E. coli is used as a criteria rather than E. typhi or the dysentery bacilli in determining possible dangerous polution of a body of water by sewage.

Bacteria in secreting their enzymes and digesting their food give off certain by-products and cause certain changes to take place within the material with which they are in contact. Complex material may be broken down by certain types and simpler compounds formed, or occasionally, the reverse takes place. Different types of bacteria will attack different substances and different elements will be affected.

Sewage, the solid material which consists largely of plant and animal matter or its waste products, contains principally oxygen, hydrogen carbon, sulphur and nitrogen. It is the last three elements and their various compounds and bacterial action thereon that we are mostly concerned.

Since matter is indestructable, it can only change in form or in combinations of its elements and under bacterial action there is a constant breaking down and building up of these combinations. This action is called a cycle and the most important of these cycles are the nitrogen, sulphur and carbon cycles. Taking the carbon cycle as an example, we find that the fats, proteins and carbohydrates of plant and animal life are partially broken down during respiration and CO2 or carbon dioxide given off. Further—following death of the animal, putrification sets in and CO2 is released. This CO2 is then taken up by plant life to be again turned into carbohydrates, fats, and proteins to be once more taken into the animal body and there again broken down.

The sulphur cycle may likewise start with the proteins of animal life to be followed by death and putrification and the breaking up of these proteins into H2S or hydrogen sulfide, with the evil odor of which, all are familiar. Hydrogen sulfide may be again broken down by bacteria into free sulphur and then further oxidized to sulfates. These may be taken up by plants or animals and reformed into proteins to start the cycle once more.

The nitrogen cycle is slightly more complex. Starting with the proteins of animal life, some nitrogen is excreted as urea and this is easily broken down to ammonia. Death and putrification also release nitrogen as ammonia. The process of oxydation converts ammonia first to nitrites and then nitrates and is known as nitrification. Denitrification may release nitrogen as the free gas, to pass away into the air. However, bacteria may reform the free nitrogen directly into proteins in plants, a process known as nitrogen fixation. Plant life will take the nitrates to form proteins and these will once more be changed to the proteins of animal life.

These cycles are of great importance to the operator of a sewage treatment plant. The foremost object of every plant is twofold. First, that there shall be no danger to human life from the disposal of the effluent due to pathogenic bacteria, and secondly, that there shall be no offense to the senses, particularly of smell from either the plant itself or the effluent.

From the time the sewage first enters the sewers it is subject to bacterial action, both aerobic and anaerobic, oxydizing and reducing. Anaerobic action is generally also of a reducing nature. Since all bacterial life must have oxygen in some form it must either be obtained from the air or it must be wrested from available compounds.

As the sewage flows through the sewers the dissolved oxygen present is rapidly used up by the aerobic bacteria and due to lack of free oxygen these forms soon die off or are greatly reduced in numbers. The anaerobes both obligative and facultative then begin their work of split-

ting off oxygen from the compounds present and reduction and putrifaction with its consequent objectionable odor result. As the sewage proceeds to the treatment plant and this action of reduction continues we speak of the sewage as being "stale." In an extreme condition of reduction, very objectionable odors and gases are produced. The hydrogen sulfide produced reacts with any iron compounds present and black iron sulfide forms to give the sewage a dark or black color. When this occurs, the sewage is said to be septic.

In the treatment of sewage, as has been mentioned before, one of the endeavors is to keep odors down as much as possible. Reduced to actual operating methods this means that the sewage must be kept as fresh as possible and oxydizing rather than reducing action must take place. Our most refined and up to date processes of sewage treatment are essentially oxydizing processes in which an effort is made to keep the sewage constantly supplied with sufficient oxygen so that the aerobic and oxydizing bacteria will thrive in place of anaerobic or reducing bacteria. The activated sludge process, the sprinkling filter, and the older type of contact bed are all methods by which sewage is so exposed to air that oxygen may be readily absorbed and the proper type of bacteria encouraged to grow.

In the case of sewage passing through septic tanks, Imhoff tanks or other types of settling tanks, but little oxygen is absorbed and a so-called septic or putrifactive action takes place due to anaerobic bacteria. The effluent from these tanks due to the almost exclusive presence of anaerobic or reducing bacteria and practically complete lack of dissolved oxygen will not only be highly offensive as to odor due to the putrifactive compounds present but will practically deplete the oxygen in any body of water into which it may be discharged. On the other hand the effluent from an activated sludge plant or other process affording good oxydation will contain not only a fair supply of dissolved oxygen but in place of the ill smelling reduction compounds such as hydrogen sulfide, ammonia and mercaptans will contain sulphates, nitrates, nitrites, bicarbonates which are relatively stable, inodorous, and inoffensive. Such ammonia and similar compounds which may be present will generally be in such small amounts as to be readily taken care of by the dissolved oxygen and the oxydizing bacteria present in the body of water in which discharged.

The solid material in sewage is settled out in the various types of settling tanks and it may be allowed to remain in them or removed to digestion tanks or chambers. In these digestion tanks the solid material is attacked by various types of bacteria and the greater part of it broken down or liquified. Material remaining after the greater part of bacterial action has ceased will generally be found to have an inoffensive or slightly moldy odor and be suitable for disposal as fertilizer or fill material without great objection. The liquid resulting from the liquefaction of this solid matter passes off with the supernatant or effluent from the tank. This liquid, from digested sludge is generally quite septic and has a high oxygen demand to satisfy bacterial requirements.

The bacterial action taking place in the digestion tanks is dependent upon several things, e.g., alkalinity or acidity of the media, the temperature, composition of the raw sludge, etc. A highly acid media does not promote the proper bacterial growth for satisfactory decomposition. The resultant by-products are highly offensive. The optimum desirable range is generally between pH 6.8 to 7.5 although some digestion tanks have been found to work satisfactorily with a pH outside of these limits.

Temperature has quite an important bearing upon the proper bacterial digestion of sludge. The normal water temperature will vary from 50° to 80° F. The energy released by bacterial action will increase this normal temperature by a few degrees but the average digestion tank will seldom exceed 80° to 85° F. In the winter when temperatures of 50° or less are encountered bacterial action is greatly reduced and may even come to a standstill during periods of extreme cold. Naturally the material in the tank does not undergo decomposition during this time and a large amount of digested material will therefore collect in the tank. With the advent of warmer weather and a warmer sewage bacterial action will start and due to the large amount available food material digestion will take place very rapidly with resultant foaming and consequent production of odors. For this reason many tanks are heated to a fairly uniform temperature throughout the year so that digestion of the sludge will proceed at a uniform rate.

One feature of sludge digestion is production of gas as noted during the discussion of the carbon and other cycles. There are certain periods in the cycle when gas is produced. This gas consists largely of carbon dioxide (CO2), methane (CH4), and nitrogen with some hydrogen sulphide. The various proportions in which these gases will be present depends not only upon the material undergoing digestion but also upon the particular bacterial flora present. For practical use it is desirable that the gas be high in combustibles such as carbon monoxide and marsh gas, and low in carbon dioxide and nitrogen which are non-combustible. Gas produced by bacteria from an extremely acid tank or from an excessively foaming tank will often have a very high carbon dioxide content and a correspondingly low B.T.U. or heat value.

For economics in plant design it is desirable that the sludge capacity be as small as possible and yet sufficiently large to provide for proper storage for complete digestion before removal from the tank. The normal period of digestion ranges from 60 to 90 days. In order to speed up digestion it was thought that so-called thermophilic digestion at temperatures up to 120° F. or the encouragement of thermophilic types of bacteria would speed up digestion and enable sludge to be removed in a matter of weeks instead of months. The high hopes of those investigating this action have not been fully realized as often the seemingly completely digested thermophilic sludge when reduced to normal temperatures would undergo very violent and further putrifactive decomposition. Gas formation during thermophilic digestion has not been entirely satisfactory and was usually of a low heat value.

Sludge deposits in streams are attacked by bacteria in the same man-

ner as in a digestion tank with the difference that there is generally more oxygen available. When, however, the stream oxygen is low or the sludge deposit becomes large in extent, the dissolved oxygen of the stream is soon exhausted and septic action occurs. The stream then becomes dark and ill smelling and fish life disappears.

Often the natural sulphates present in water are attacked and reduced to sulphides with resultant odor. The sulphates in these waters carrying sewage through sewers are first reduced to sulphides. The sulphides on escaping from the sewage collect in droplets on the sides of the sewers above the water line where they may be subsequently oxidized to sulphuric acid. This acid then attacks the sewer structures above the water line causing heavy damage and even ultimate destruction. The normal alkalinity of sewage will generally neutralize any sulphuric acid formed in the sewage itself and hence, little or no destruction will take place below the water line.

Of the higher bacterial types present in sewage, of particular interest are Beggiatoa, Leptomitus, Sphaerotolus and similar species. Beggiatoa or sulphur bacteria is generally found wherever hydrogen sulphide is present in appreciable amounts. Leptomitus is encountered in a similar habitat. These organisms exist in hydrogen sulphide bearing water and convert the gas to sulphuric acid. Granules of free sulphur may be seen within their cells. Their growth may often become so great that they will clog sewers and screens. Their growth along streams receiving raw sewage or a not too well oxidized effluent produce unsightly patches of grayish white filaments resembling dirty cotton waste or sheep's wool. When growths are heavy these patches break off, float downstream and ultimately die and decompose, causing further offense from odor.

Sphaerotolus is a fine filamentous organism and is often the curse of the activated sludge plant operator. It grows prolifically in new sewers where the water is soft. For reasons not as yet thoroughly understood or determined, heavy growths of Sphaerotolus will suddenly occur in the activated sludge. These heavy growths are generally considered to be the cause of bulking of sludge. These organisms are also present in this digested sludge. High carbohydrate content of sewage is thought to have some bearing on the encouragement of these growths, but experiments toward proving this have not been entirely conclusive as yet.

THE BEAUTIFICATION AND IRRIGATION OF GOLDEN GATE PARK IN SAN FRANCISCO, CALIFORNIA, WITH AN ACTIVATED SLUDGE TREATMENT PLANT EFFLUENT

By CHARLES GILMAN HYDE, Professor of Sanitary Engineering
University of California, Berkeley

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SUPERVISION OF SEWAGE DISPOSAL PLANT OPERATION BY THE DESIGNING ENGINEER

By G. A. PARKES, Assistant Engineer
City of Los Angeles

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CHARGES FOR SEWER CONNECTIONS FROM OUTSIDE AREAS TO CITY SEWER SYSTEMS

By JEAN L. VINCENZ*

The problem we are to discuss is much larger than the consideration, merely, of the amount of charges to be made for sewer connections. It is the larger scope of this problem, including consideration of the health angle and of city policies, that causes the amount of interest that has been displayed in this subject.

In order to develop information for this subject, a questionnaire was recently sent out by the League of California Municipalities to the cities of this state and the answers are rather illuminating. The first question was, "Do the inhabitants immediately outside the city limits, in the unincorporated area, have a sewage problem?" Here are several answers. This from the City of Arcata:

> Yes. Land around Humboldt State College, outside city limits, is being built over rapidly. People use septic tanks, which in clay soil are not satisfactory. These people build outside to avoid city taxes, but want sewers, lights, fire and police protection. City refuses to take on more sewers on grounds present mains are inadequate.

This one, from Livingston:

> No. The soil here is deep, sandy loam and individual houses have no difficutly in providing adequate sewage disposal by means of small, septic tanks and loosely laid tile drains.

And here is one from the City of Martinez:

> In two subdivisions the situation became so bad that sanitary districts had to be formed. One of these districts provided for itself a complete sewer system, independent of the city. The other succeeded in persuading the city to allow them to connect to the city sewer system with the understanding that they would, in due course, annex themselves to the city.

These answers show that the problem varies in its seriousness, according to local conditions, depending somewhat on the type of soil, the contour of the land and the degree to which the adjacent territory is built up.

*City Engineer and Commissioner of Public Works, Fresno, Calif.

Having these factors in mind, I will not attempt to give you the solution for the problem in all of the cities of this state. Four prominent city engineers will follow me in discussing this problem and will present the problem, particularly in their localities and the solutions they find best in those localities, together with their thought on the general problem.

One reason for the seriousness of this matter to the cities of California is the fact that, when the sewage problem becomes a distinct menace in the territory outside and adjacent to a city, this menace is as great to the residents of the city as it is to those in the unincorporated area, for you know as well as I that the little germs and bugs are not intelligent enough to know that the taxpayers of the City of Fresno have a modern, up to date sewage system for which they are paying taxes and, therefore, should not be bitten by the germs. Neither are the germs wise enough to distinguish between my children, who live within the city limits, and those children who do not. When conditions get so bad in these districts that the sewage overflows in the back yards and runs down the driveways into the streets, real danger confronts the entire community.

One of the first thoughts that occurs to us is: Cannot the health authorities compel the people of these districts to annex to the city, so they may have adequate and proper sewage disposal? Of course, we find that they cannot. Then, can they compel them to form a sanitary district, disposing of their sewage in an approved manner? Again, we find, by consulting the state law, they cannot. The health officers in the county do have the authority to condemn unhealthful nuisances and to order that the nuisances be abated, but they are powerless to say, "This is the remedy that must be taken by you." Their program of correction can only be by indirection; by suggestion. I shall have more to say on these points later.

Now, it has been suggested that sewer lines might be extended into the outlying districts, giving those residents the opportunity to connect with the sewer, which, in turn, connects to the city's disposal plant. It is proposed that these residents should pay a fee for such service. This is not as simple as it sounds at first hearing. In the first place, you are confronted with the problem of who shall pay for the extensions. In some cases, the subdivider makes the extensions. Possibly, the city might do so, making the extensions and charges in a manner similar to those of a water department. However, our case is different, for people must have water and, if they refuse to pay their bill, shutting off the water supply generally brings quick payment. Not so with sewage disposal. You may cut off the connection, which is more difficult to do, for non-payment, but how are you going to force collection? Particularly, from renters. I grant you that these problems may be able to be worked out by the passage of certain laws. However, it is definitely the feeling of all of us, I am sure, that the proper solution is the annexation of these adjacent territories to the cities, in order that they may receive a proper sewage disposal service.

Because of the health problem involved, we of the cities should probably be very altruistic, but, may I recall to you again, from the questionnaire, the experience of the City of Martinez where one district was allowed to connect with the city sewer system with the understanding they would, in due course, annex themselves to the city and, note this, since then two annexation elections have been held, resulting in defeat.

In San Diego one sanitary district and two sewer maintenance districts were formed outside of the city in an endeavor to handle this problem. Here is a quotation from the San Diego report: "The situation, at present, is unsatisfactory, both to the city and to the residents of the district." Here again is the experience of the City of Arcata, above referred to, in answer to the question, "What is your policy toward outside sewer connections?"

> Formerly permitted connections on annual rental basis. Many are delinquent in payment, following refusal of state to pay $25.00 per year for State College—no permits now granted.

Because this problem is so immediate to the City of Fresno and because it falls immediately under my jurisdiction and also because I happen to be manager of the city owned water department. I have given this problem quite a lot of study. But, I am convinced that a sewer rental plan for homes outside the city will not be successful for our locality and, yet, the problem is definitely there from a health standpoint, as it is in any other city in the state. Certainly, if a plan can be worked out that will be fair to the city, there are certain basic principals that must be considered in fairness to the taxpayers of the city:

1. The property owners should pay for the sewer installation from the city mains to their premises and the work should be done under the supervision of the city authorities.

2. In computing the rates to be charged, cognizance must be taken of the original cost of the sewer mains through the city and, also, that of the outfall sewer or sewers, the interest paid by the city thereon and a depreciation charge, based on a reasonable life of the sewers.

3. With the allowance for interest and depreciation, must be added the maintenance charges. In this connection, all of you, undoubtedly have studied the schedule of rates of sewer rentals, compiled by the AMERICAN CITY MAGAZINE, from a great number of cities of the United States. You will recall that these rates will run as high as twenty-five or thirty cents per thousand gallons down to as low as two cents per thousand gallons. Certainly, in setting rates for the territory in question, these rates should be high enough so the residents must, definitely, consider annexation to the parent city. A charge of $12 per year on a flat rate basis for a residence would seem to be a minimum, in addition to a charge for the extension and connection of the mains. In my opinion, this charge should be high enough, so that those who receive service are not doing so at the expense of the city taxpayers and, also, high enough that it would tend to force annexation. It certainly should be no lower than their present cost, which

would have to include a new septic tank or cess pool every five years or so and, also the cost of pumping out and cleaning them. In my opinion, if a charge of $12 to $18 per year, payable in advance, could be made and collected, this would be about the present cost to those residents who have cess pools where the soil is not of a sandy character. Also, such a charge would, definitely, bring the difference in the cost of taxes very close together.

The problem of serving industries outside the cities has not yet been mentioned and yet it is very important. The principles just enumerated for connections to homes should be followed in dealing with these industries. Consideration must be given to the type of sewage coming from these industries, as it is well known that the wastes from some industries are far more difficult and costly to handle than from others.

The City of Fresno is preparing an ordinance at this time to meet the problem of industries outside the city limits. A number are now connected to our sewer system, having paid the cost of the sewer extensions from the existing sewer mains and pay an annual fee of $150 in advance. I have been compiling a table of rates for these industries, based on the flow of water consumed. The recommendation will be made not to lower the minimum rate of $150 per year and, based on a sliding scale of from five cents per thousand gallons to two cents per thousand gallons, rates will be established above the $150 mark.

I hope these remarks may be of some assistance to you in working out this problem in your localities and I am giving way now, so the other speakers may discuss the problem as they see it.

In conclusion, may I say, however, that we cannot minimize the health problem and the danger of serious epidemic that confront all of the cities. While I have pointed out to you that the county health officers and the state health officials do not have as much authority as it would seem they need in this matter, yet we must have the wholehearted support and cooperation of these health officers to protect the health of our community. There is no reason whatever for any health officer's being so weak-kneed as to allow cess pools to get in such a condition that sewage is actually in the yards and under the very windows where children sleep and, yet, this is the case. Any health officer who does not have the backbone to do his duty under these circumstances should be immediately removed from office and I feel that the cities of California are entitled to the utmost cooperation from the county supervisors to see that such health laws as we do have are rigidly enforced in these matters, for it cannot be overlooked that the city taxpayers are helping to pay the salaries, not only of the county supervisors but of the county health officers, and are entitled to the full protection these health officers are supposed to give. With aggressive and wholehearted action by the county health officers, in dealing with this problem; with seeing that overflowing cess pools are pumped out or replaced promptly and, with a proper safeguard of the community in this matter, the residents of the territory outside the city limits will have this problem called to their attention so repeatedly that they

will recognize not only its seriousness to the public health, as well as to their own health, but that the cost of maintaining insanitary sewage systems is even more expensive than the cost of annexing to the city and becoming an active part of, instead of a parasite on, the community in which they earn their daily bread.

SEWER CONNECTIONS FROM OUTSIDE AREAS CONNECTED TO THE CITY OF PALO ALTO SYSTEM

A DISCUSSION OF A PAPER BY JEAN L. VINCENZ

By J. B. Byxbee*

While there are no established rules regarding connecting of outside areas to the Palo Alto Sewer System, it is the practice to allow such connections to be made on condition that the applicants agree to pay the city rental for this service as determined by the Board of Public Works.

The records at present show that there are about a dozen residents enjoying this privilege on the basis of a rental charge of $3 per year One auto camp, with 21 cabins, pays $30 per year, and one bungalow court, with 4 small residences, pays $7 per year.

All of these places face on boundary-line streets where they are city sewer mains. No extension of the sewerage system has been made thus far to serve districts located outside the city limits. Stanford University and its campus has its own sewerage system with final disposal at the Palo Alto Sewage Treatment Plant. The population of this district is approximately 5000, and the average flow amounts to 550,000 gallons per day, or about 32% of the total amount of sewage handled at the plant.

A special contract has been entered into between the City and the University whereby the latter is obligated to pay its proportionate share of interest and bond payments on the capital invested in the plant, the cost of maintenance and operation, and any other incidental costs connected therewith. The proportionate share is based on the volume of flow which, at the present time, amounts to about 32% of the total flow, as indicated above. For the year 1936-37, the total cost for fixed charges, and operating and maintenance of the plant and outfall line, was $14,194, of which Stanford University paid $4518.

The Stanford Convalescent Home is also connected to the Palo Alto system and pays rental on the proportionate volume basis. This rental now amounts to some $92 per year. The Home takes care of approximately 100 children, and the average daily sewage flow amounts to 9700 gallons.

The rental rate of $3 per year per residence was established a number of years ago, before the installation of the sewage treatment plant.

*City Engineer, Palo Alto, Calif.

It is entirely too low and should be revised. The fixed charges and maintenance and operating costs of the Sewerage System and sewage treatment plant at Palo Alto now amounts to some $25,000 per year, or $58.50 per million gallons, based on the total metered flow of 427,000,000 gallons. The average residence might house 4 persons and discharge about 375 gallons per day into the system or approximately 0.137 million gallons per year. Multiply this by the above estimated unit cost and it is seen that a charge of $8 should be made for the residence connection. To this there should be added perhaps 25% for contingencies and profit, which would indicate that the yearly cost for the connection should be $10.

The outlying districts around Palo Alto are rather sparsely settled and thus far no serious public health menace has resulted from the use of cesspools and septic tanks. In many places the ground is gravelly, where cesspools and septic tanks operate satisfactorily and at minimum expense. In clay and adobe soil, however, such methods of disposal are expensive and insanitary.

As Mr. Vincenz states in his report, there seems to be no practical way whereby outlying sections might be forced, through annexation to the adjoining city, to eliminate insanitary and unsafe conditions. The great dread of added taxes seems to possess the residents of those districts to the point where they appear to be willing to sacrifice health rather than to pay city taxes. Palo Alto, however, is probably in a better position to coax these districts into the city than most localities due to certain advantages it has to offer, as follows:

1. It can generally be shown that residents in such districts can save more than the tax increase by the reduction in cost of utilities. Palo Alto owns its water, power and gas utilities, and serves these commodities within the city at rates substantially lower than the outside rates.

2. The extension of fire and police protection to the outside residents is of considerable moment. At present, when a fire occurs outside of Palo Alto, the city department will run its apparatus to the city limits nearby and there stop. No effort will be made to save the outside property even though it is well within the reach of the water and fire fighting equipment.

3. The extension of the sewer mains to an annexed district is done without specially taxing the district and this helps to win the annexation election. The district comes in with the understanding that it will pay only the city taxes and that the sewerage system will be extended at the expense of the city as a whole.

4. Water is scarce around Palo Alto and an annexation election can usually be carried when it is shown that the district will receive an ample supply of water without any cost to the residents for construction of the mains.

These concessions that the city makes are quite costly and are considered by some to be too liberal, but the experience in Palo Alto, ex-

cept in several minor cases, has been that the normal increase in property values and taxes, and corresponding increase in utility revenues, makes the annexation a paying investment, notwithstanding the money sunk into it during the development period after annexation.

DISCUSSION OF PAPER BY MR. JEAN L. VINCENZ ON CHARGES FOR SEWER CONNECTIONS FROM OUTSIDE AREAS TO CITY SEWERAGE SYSTEMS

By LLOYD ALDRICH*

In preparing a discussion of this subject the writer has referred to the data obtained from various cities of this State in reply to a recent questionnaire on matters relating to this subject. This data is divided into four divisions, the first relating to unincorporated areas immediately outside of the city where the inhabitants do not obtain satisfactory conditions by the disposal of household sewage into cesspools. Concerning the City of Los Angeles, there are ten separate unincorporated areas either adjacent to or surrounded by the city limits, which vary in size from 100 acres to 9400 acres with populations varying from 80 to 5300. It is estimated that the 1937 population for these ten areas has a total of 9600 and an acreage of 18,770. All but one of these areas have no facilities, other than cesspools, for the disposal of their sewage, and the inhabitants of such areas are increasingly becoming dependent upon the Los Angeles sewerage system for relief. The location of these areas is shown on the following Table A:

TABLE A
POPULATION OF UNSEWERED UNINCORPORATED AREAS OUTSIDE CITY LIMITS

DISTRICT No.	Name	Tributary Acres	POPULATION 1930	1937	DISTRICT No.	Name	Tributary Acres	POPULATION 1930	1937
1	2	3	4	5	6	7	8	9	10
1	Baldwin	1895	1500		7	Rafael	820		
2	Ballona	5340	1600		8	Rio	100		
3	Crescenta	9420	5356		9	Sanford	11	22	
4	Duquesne	110	8		10	W. 3rd St.	310	87	
5	Franklin	195	3						
6	Moynier	570	170			TOTALS	18,771	8,746	9600*

*Indicates estimated.

In addition to the ten County areas, which are not provided with sewage disposal facilities, there are five other unincorporated County areas, six County Sanitation Districts, and ten other cities, or portions thereof, that have contracted with the City of Los Angeles for disposal of their sewage or a part thereof into the Los Angeles system. The Los Angeles system of sewage disposal is thus of a metropolitan character, and provides at this time for a population of 190,100 outside of its boundaries, and for a total population of 1,400,000 at its

*City Engineer, Los Angeles, Calif.

Hyperion treatment plant. In the Harbor District of Los Angeles, the sewage from a population of 60,000 in the San Pedro and Wilmington sections is treated at the Terminal Island plant. Owing, however, to topographical conditions, the sewage from a portion of the City having a population of 38,000 is discharged into the system of the County Sanitation Districts of Los Angeles County.

Two of the six County Sanitation Districts, above mentioned, include portions of Sanitation Districts 2 and 5, the others being the entire areas of Sanitation Districts 4, 9, 11, and the South Bay District, which includes the cities of Redondo Beach, Hermosa Beach, and the westerly portion of Manhattan Beach. The population from these six districts thus tributary to the City system, is estimated at 62,250 in 1937 and has an average flow of 4,655,000 gallons per day.

Contracts for the disposal of sewage from the tributary portions of these six County Sanitation Districts into the Los Angeles system were made by each of these districts with the City of Los Angeles in 1925, 1926, or 1931. These contracts provided that the City of Los Angeles will receive and dispose of a specified amount of sewage flow from the districts, and the districts agreed to pay the City for said flow at a rate of $28,916 per second foot or rated flow of 448.8 gallons per minute of sewer capacity purchased. As the amount of flow specified was determined by allowing for future development of the districts, it is probable that in most cases it will be many years before the district flow will exceed the specified amount. For the reason that these outside areas paid cash they have not been charged for interest on the bonds.

In addition to the payment for the capacity purchased, the districts further agreed to pay the City at the end of each fiscal year such proportion of the annual cost of the maintenance of the Outfall Sewer System of the City between the point of connection of the district with the City system and the Hyperion treatment plant, as the quantity of sewage discharged into the outfall system from the district bears to the total amount of sewage delivered at the Hyperion plant from all sources. The contracts also required that the districts shall pay the City the same proportion of the annual cost of the maintenance and operation of the Hyperion plant and ocean outlet therefrom.

These contracts are binding as long as the City maintains and operates its outfall system. The contracts also state that Los Angeles shall have the right to discharge into the district system all sewage which flows by gravity thereinto from adjacent territory within the City specifying, however, the maximum amount to be received from such city territory. In these contracts, it was specified that the district shall require all persons within its boundary using sewers which discharge into the City system to comply with requirements which the City makes with regard to those using its sewers within its boundaries.

In accord with these County District agreements, the City of Los Angeles has yearly determined the average amount of flow from the district into the City system, and billed each district for its share of the maintenance of the outfall and treatment plant of the City.

The following Table B shows the sewered population and sewage flow in 1930 and 1937 from the six County Sanitation Districts, also from the five other unincorporated areas in the County which are tributary to the City system, two of these areas being the Soldiers Home in the Sawtelle District and the Universal City area. This table also gives the population of, and the sewage flow into the City system from, each of the ten cities above noted.

The second division in the paper of Mr. Vincenz asks what is the policy of the city toward permitting outside sewer connections to be made to the city system. For the City of Los Angeles, it has been the policy to permit no individual connection to be made to the City system unless a contract has been made for sewage disposal with the County section containing the property of the applicant. Where no contract has been made with such outside areas, it has been considered that such areas must annex to the City if they are to receive the benefit of sewage disposal. By such annexation the property within the annexed area assumes, by the payment of its taxes, its proportion of cost of the operation and maintenance of the City sewerage system.

For outside County areas to be permitted to dispose of their sewage into the City system without annexation to the City, or agreement with the City by the County Sanitation District which would include the area in question, such sewage disposal is not fair or just to the property owners of the City of Los Angeles as the use of their system should be only by such definite prior arrangement. Furthermore the cost of inspection of outside sewer connections without such arrangement would be indefinite, as there would be no authority for the City to make such inspections or collections therefor. As the ten County areas above noted are not included in any County Sanitation District, these areas should from a sanitary angle be annexed to the City so as to eliminate the present method of cesspool disposal.

The third division of the paper relates to the number of lots in outside areas served and charges made therefor. The following Table C gives a list of such lots which have been served by the City of Los Angeles in 1936, the contract charges paid for sewage disposal from such areas, and the yearly charges paid by such areas in 1936 for maintenance and operation.

The fourth and last division of the paper tabulates the amount of fees paid for inspection of connections from outside areas. The City of Los Angeles charges inspection fees for border line connections only. The charge here is similar to those made in the City area, namely, $1.50 for the first permit and inspection, and $1.00 for an additional inspection. For connections to special or bond sewers the City charges $10.00 per connection in addition to a special cash assessment of $1.35 per front foot of property benefitted. For the addition of a new Y or T to the sewer a charge of $5.00 is made.

In the paper of Mr. Vincenz, he has suggested that, as the health authorities cannot compel the people in the areas outside of the City limits to annex their districts to the City, or to form a sanitary district for the disposal of their sewage, that laws may be passed which will

TABLE B

SEWERED POPULATION AND SEWAGE FLOW FROM OUTSIDE AREAS WHICH HAVE CONTRACTED WITH CITY OF LOS ANGELES FOR DISPOSAL OF SEWAGE INTO THE LOS ANGELES SYSTEM

LOCATION No.	LOCATION Name	TRIBUTARY ACRES	POPULATION & DENSITY PER ACRE 1930 P	1930 D	1937 P	1937 D	DAILY AMOUNT OF SEWAGE FLOW 1930 MGD	1930 G.C.	1937 MGD	1937 G.C.
1	2	3	4	5	6	7	8	9	10	11
1	Alhambra	33	300	9.1	180(1)	5.4(1)	.02	60	.01(1)	65
2	Beverly Hills	3336	17429	5.2	24800	7.4	1.43	85	2.38	95
3	Burbank	10400	5000		8200		.65	130	1.44	175
4	Culver City	2075	5669		6800					
5	El Segundo	2280	2500		3120		.15	60	.21	66
6	Glendale	12300	35000		56000		3.3	97	6.38	114
7	San Fernando	1455	4000(2)		6000(2)					
8	Santa Monica	5080	37146	7.3	43700	8.6	2.6	71	3.28	75
9	Soldiers Home	680	4630		5630		.53	115	.65	115
10	So. Pasadena	232	1030	4.3	1500	6.5	.03	29	.05	36
11	Universal City	325							.03	
12	Vernon	1315	1269		1700					
13	So. Bay District	2300	12000	5.2	14500	6.3	0.60	50	1.04	71
14	C.S.D. No. 2	950	8000	8.7	10100	11.0	.36	45	.71	70
15	C.S.D. No. 4	1594	17030	10.6	20540	12.9	1.56	92	2.00	97
16	C.S.D. No. 5	1604	13000	8.1	15630	9.8	.52	41	.64	41
17	C.S.D. No. 9	140	400	2.8	500	3.6	.02	50	.025	50
18	C.S.D. No. 11	1304	500	.4	1000	0.8			0.24	
19	Livonia Ave. Dist.	100			100				0.005	
20	Gilmore Stadium	10			250(3)				0.015	
21	Pan. Pac. Aud.				140(3)				0.008	
TOTALS		47513	164903	61.7	220390	72.3	11.77	925	19.113	1070

NOTES: (1) Indicates net population and flow due to interchange of sewage disposal facilities.
(2) Indicates population tributary to San Fernando Treatment Plant.
(3) Indicates equivalent population based on 60 gals. per capita.
(4) Items 9, 11, 19, 20, and 21 are the five unincorporated County areas referred to in this report.
(5) Items 13 to 18 inclusive are the six County Sanitation Districts referred to in this report.
(6) On Aug. 1. 1937, sewered populations within the City of Los Angeles of 34,420 and 3548 were tributary to the systems of County Sanitation Districts 1 and 5 respectively.

provide for such disposal. As above stated, the matter of cost to be paid by the people in the outside areas for the extension of the Sewers to these areas, and for the disposal of sewage therefrom into the City system, requires a definite contract, if such areas are not annexed.

During the past ten years, efforts have been made for the passage of a law in the State of California which would permit of the collection of a rental for the use of a sewerage system from the owners of property which it would serve. In 1935 and 1937, bills which would provide for the construction, maintenance, and operation of such systems on the rental basis were not successful in obtaining the signature of the Governor, although they were approved by the Legislature. The passage of such a law could form the basis for a charge or fee to be paid by those in the outside areas, and it is recommended that efforts again be made to have such a bill submitted and adopted by this State.

Due to the fact that the City's trunk lines are reaching capacity, making it necessary to construct relief sewers, and the condition in the outfall sewers is such that it has become necessary to commence the design of an additional outfall as well as a new treatment plant, it has become the policy of the City to preserve the remaining capacities in the system for the benefit of the tax payers of the municipality and areas that may be annexed, declining requests from such outside areas as are not now under contract, and wish to dispose of their sewage into the system, but otherwise remain independent.

In making a study of sewer rental for Los Angeles, it was found that a minimum charge of $3.00 per connection per year, $7.40 per connection per year in residential areas, $25.00 to $75.00 per connection per year in commercial areas, and $50.00 to $170.00 per connection per year in industrial areas would provide the amount required for the construction, operation, and maintenance of the sewerage system needed for the treatment and disposal of sewage from the City and such outside areas. These charges vary from 6 to 2 cents per thousand gallons, but it is evident that local conditions in any other city would modify data given for Los Angeles.

TABLE C

CONNECTIONS IN OUTSIDE AREAS SERVED BY LOS ANGELES AND CHARGES MADE THEREFOR

LOCATION		No. of	CHARGES	
No.	Name	House Connections	Contract	Maintenance
1	2	3	4	5
1	Alhambra	82	$ 2,227	$ 40
2	Beverly Hills	5845	144,580	2,580
3	Burbank	2040	220,000	1,240
4	Culver City		54,940	
5	El Segundo	825	12,000	190
6	Glendale	13903		7,320
7	San Fernando			
8	Santa Monica	11300	342,263	17,210
9	Soldiers Home	1	10,000	620
10	So. Pasadena	365	22,808	120
11	Universal City	1		1,650

LOCATION No.	Name	No. of House Connections	CHARGES Contract	Maintenance
1	2	3	4	5
12	Vernon	----------	----------	----------
13	South Bay District	3270	40,000	970
14	C.S.D. No. 2	2477	78,084	660
15	C.S.D. No. 4	5008	164,820	2,280
16	C.S.D. No. 5	3558	130,140	660
17	C.S.D. No. 9	120	2,800	50
18	C.S.D. No. 11	3	18,217	440
19	Livonia Ave. District	80	----------	10
20	Gilmore Stadium	1	----------	20
21	Pan-Pacific Auditorium	1	----------	10
	TOTAL	48,880	$1,242,879	$36,070

NOTES:
1. The amounts in Column 5 include a charge of 15% for Administration.
2. Amounts in Column 5 have been paid and figures shown are correct to the nearest $10.00.
3. The data given for Alhambra indicates the connections from Alhambra into the Los Angeles system.
4. An estimate of $40,000 given in the replies to the questionnaire as income received by the City of Los Angeles from outside areas during the past year is approximately the sum of the amounts in Column 5, no income having been received by Los Angeles during the past year.
5. The totals for Columns 3, 4, and 5 are approximate as the data in these columns for some of the locations is indefinite, or cannot be expressed in figures.

DISCUSSION OF PAPER BY MR. JEAN L. VINCENZ ON CHARGES FOR SEWER CONNECTIONS FROM OUTSIDE AREAS TO CITY SEWER SYSTEM

By W. L. POPP*

The problem of the amount to be charged for outside sewer connections to City system (where the topography, soil conditions and density of population reaches a certain point, it is more economical to dispose health menace) is comparatively simple. The charge then can naturally be based on an equitably fair cost for such service.

We all know that isolated dwellings can be sewered most economically by properly constructed cesspools or septic tanks. When the density of popuation reaches a certain point, it is more economical to dispose of wastes through a sanitary sewer system, and logically, the City can deal with them upon a business basis.

However, an entirely different problem presents itself when the conditions are such that these areas constitute a health menace to the residents of that City. After watching this situation, not only in San Jose but in other cities, over a period of years, it appears in general that the same factors and forces present themselves in all localities,

*City Engineer, San Jose, Calif.

whether it is a small community or incorporated City, the principle of gone out of the City limits to have more freedom and low taxes, or whether it is a small community or incorporated city, the principle of trying to get cheaper service than the City is willing to give them, is always evident.

Unquestionably, out of self-protection, the City must make some concessions. I believe that more can be done by proper education and by making reasonable concessions, explaining to our own taxpayers that health protection is of some value, rather than by attempting to force through County Health Officers, or State Health Departments, these people to follow the dictates of the City.

I appreciate there is no legal way of the City doing it but the attitude of telling them they they must form sanitary districts or assessment districts. I appreciate it takes time to put over any educational program, but the City officials and representatives can do a great deal of good work by contacting leaders of the groups in question, and admitting certain apprehensions on the part of the City; also offering of the free engineering service that may be possible in order to build up good will. In the long run, the very great majority of these cases annex to the City, and the time of their annexation can be lessened by this building up of good will. I may seem optimistic but believe I realize, through sad experience, that many individuals have only gone into incorporated cities to not be bothered with community problems, but the majority can be won over. So far, I have not perhaps given you a great deal regarding charges, but I am attempting to lead up to that point, in order to justify charges less than the actual cost to the City.

In San Jose, we charge $50.00 for permission to join to the City sewer system, and 20 cents for each $100 of assessed valuation of the property connected, per year, as rental. The permittee is requested to sign an agreement where the City reserves the right to disconnect any time, and to have a lien on the property for any unpaid amounts. The permit is given subject to connections being made to the satisfaction of the City Engineer and the plumbing in the establishment passed upon by the Plumbing Inspector. Each permit is granted individually by the City Council. When it comes to industries or large institutions, the permission to connect is granted after a thorough study of the problem and special agreement as to rental charges are made. A good example of large institutions in what happens by the way of the establishment of good will, can be recited in the case of the so-called Southwest Annexation District. Several canneries had been connected to the City sewer system for some time, subject to all regulations as to protection of the sewers and character of sewage, etc. It has been only a matter of a very short time that City officials were able to sit down with the operators of these institutions (some 6 or 7 in number) and explain their problems as to fire protection, more adequate sewage, etc. Being business men they sponsored an annexation and it was carried with no difficulty whatsoever. I believe that allowing them to connect at nominal charges, when they had serious problems, did a great deal to foster annexation. Naturally, we have some delinquents in the way of small

home owners, but the problem over a period of many years has not been serious as compared to health menace.

We had another example in the case of the City of Willow Glen. This was a large community that presented a problem after it exceeded a population of 2500. In this instance, we allowed outside connections on boundary line streets, but, naturally felt that a community of that size could only handle its problem as a City. In that instance, after the City had grown to a population of around 4500, propositions were made based on a true cost of service. We felt that it was only a question of time that they would be satisfied that annexation was the proper solution. That annexation was speeded up by our being able to work out a WPA project for the sewering of the entire district with the City of San Jose as sponsor, at a much lower cost to them than if they handled it by themselves. Here again the spirit of good will by the officials of the two cities was a major factor in solving the outside sewer problem.

Although I may give you the impression that we are somewhat easy, we continually and watchfully guard the interests of our citizen. We have not granted sewer connections to individuals without examining the possibility of the opening up of subdivisions in the Hinderland—in other words, the possibility of bootlegging connections.

Each permit is granted after investigation, and the proviso for disconnection at any time, gives us the power to protect against the situation getting out of our hand.

For your information, we have two special cases, besides the usual ones:

(1)—We serve a colony of the Agnew State Hospital, with a population of some 1200. The rate is based on a 25-cent per capita average yearly census. I appreciate again, that this is a low charge, but they are located several miles below the City on the Outfall system where our capacity is great.

(2)—A distillery located near the State Institution above referred to, is another one of our customers. Here again they are under special permit granted by the City Council and subject to cut-off on 30-day notice and provisions as to treatment of sewage when necessary.

Both these institutions are so located that they do not interfere with our peak loads, even when our system is running to capacity.

I have not, in this discussion, given you any formula for the charge for outside sewer connections, as I do not believe that any set rule is possible. After all, outside sewer connections are privileges or concessions granted by the City. In arriving at the amount to be charged, I can only suggest that the following factors be considered:

(1) Actual cost of such service to the City.

(2) Benefit to the City by reason of reducing health menaces.

(3) Benefit derived by up-building surrounding territory by bettering the character, though with the accompanying reflection of increased valuations within the City itself.

(4) Establishment of good will with its natural reflection on business within the City.

ROSTER OF CERTIFIED OPERATORS
CALIFORNIA SEWAGE WORKS ASSOCIATION

Name	Address	No.	Grade
Alexander, Charles F.	706 Harris St.—Corona	63	3
Allen, William A.	1118 No. Hudson Ave.—Pasadena	7	1
Argetsinger, Wayne W.	682 Palisade—Pasadena	91	3
Arnold, Gerald Eugene	477 Colon Ave.—San Francisco	54	1
Barr, Harry Robert	Rte. 1, Box 302—Redondo Beach	10	2
Bell, Robert H.	1300 Pennsylvania Ave.—Colton	77	3
Bennett, Schuyler Mount	3004 Petite Court—Los Angeles	82	2
Berg, William Franklin	2512 Foothill Blvd.—San Bernardino	98	2
Beyer, Adam Carl	171 Second St,—San Francisco	52	2
Boty, Ben L.	2077 Lugo St.—San Bernardino	96	2
Boxall, Frederick G.	267 Poplar St.—Brea	57	2
Buck, Samuel B.	3224 Brandon St.—Pasadena	87	2
Castro, Albert Joseph, Jr.	1065 Alviso St.—Santa Clara	39	1
Clark, Benjamin Harrison	54 So. Craig Ave.—Pasadena	80	2
Clark, John A.	2644 Dwight Way—Berkeley	2	1
Clark, James Cummings	603—14th St.—Huntington Beach	14	2
Coffin, George H.	City Sewer Plant—El Monte	104	3
Congdon, Walter Newell	Box 315—San Juan Capistrano	93	2
Copley, Harold A.	726 No. Emerson St.—Monterey Park	82	2
Copley, Henry Weldon	328 No. Elizabeth Ave.—Monterey Park	90	2
Corrao, Joseph	854—31st Ave.—San Francisco	67	2
Cox, Byron Lloyd	429—2nd St.—Oxnard	64	3
Daley, Albert Cowles	1191 No. Los Robles Ave.—Pasadena	45	1
DeMartini, Frank E.	San Francisco Water Dept.—Millbrae	59	2
Ellinger, Morris	Lake Arrowhead	40	1
Ely, Hamlin M.	1945 So. Euclid—Ontario	31	1
Fetter, Rollin J.	1615 Obispo Ave.—Long Beach	21	2
Foster Herbert B., Jr.	377 Coventry Road—Berkeley	11	2
Fiscus, A. E.	1637 Bay View Ave.—Wilmington	34	1
Francis, Joseph A.	1428 V St.—Sacramento	101	3
Fraser, Archibald	Park Lodge—Golden Gate Park San Francisco	33	1
Freer, Paul H.	44 So. Craig Ave.—Pasadena	86	2
French, Anthony S.	2049 Crary St.—Altadena	83	2
Fritsch, Harry N.	3140 Lynwood Road—Lynwood	29	2
Gardner, R. T.	56 So. Third St.—Salt Lake City, Utah	58	2
Gellatly, Myrle K.	2143—248 St.—Lomita	25	2
Gilkey, A. E.	332 Pleasant St.—Roseville	6	2
Goudey, Raymond F.	3845 Aloha St.—Los Angeles	78	1
Graham, Frank C.	430 No. Sierra Madre Blvd.—Pasadena	66	2
Grahek, Joseph L.	171 Second St.—San Francisco	65	3
Grant, Arthur John	621 Thalia St.—Laguna Beach	71	3
Guthrie, Bruce	3101—I St.—Sacramento	102	3
Hall, James Dewey	718 West Mariposa Ave.—El Segundo	12	2
Harmon, Judson Adams	478 So. Shaffer St.—Orange	1	2
Harrington, J. H.	2205 E. 28th St.—Signal Hill	61	2
Hardwick, Albert Lester	734 Webster St.—Palo Alto	42	3
Hatch, Alonzo H.	1745 W. 42nd Place—Los Angeles	48	2
Herrick, Jack	763 W. E St.—Colton	79	3
Horne, Ralph E.	161 Eastern Ave.—Pasadena	85	2
Horton, Frank Curtis	205 W. 118th Place—Los Angeles	36	2

Name	Address	No.	Grade
Hoskinson, Carl M.	1140—43rd St.—Sacramento	103	2
Hubner, Ludwig	757 College Ave.—Palo Alto	43	3
Ingram, William Truitt	1111 College Ave.—Stockton	38	2
Jennings, John Carl	4465 G St.—Sacramento	56	2
Kinsman, Frederick	725 Walnut Ave.—Burlingame	94	3
Kjellburg, Gunnar	4411 Roubidoux Ave.—Riverside	27	2
Krause, Raymond A.	220—9th St.—Chino	106	2
Mauldin, Philip Luther	1252 W. 97th St.—Los Angeles	15	2
May, Harold L.	1192 Britton Ave.—San Jose	41	2
May, Ira C.	1716—40th St.—Sacramento	105	3
McDonald, Laurance R.	70 N. Roosevelt Ave.—Pasadena	92	3
McKay, Charles Lawrence	3716 E. Green St.—Pasadena	50	2
McMillan, John D.	City Hall—Newport Beach	69	2
Moncrief, Orlo	821 Kilson Drive—Santa Ana	75	2
Mooney, Clarence R.	413 W. Elm St.—Compton	23	3
Norman Charles Sherwood	307 W. Oak Ave.—El Segundo	28	2
Parkes, G. A.	1924 Lemon Ave.—South Pasadena	37	1
Peightal, William H.	2233—255th St.—Lomita	20	3
Porter, Harold	City Hall— San Mateo	46	2
Post, Fred W.	Rte. 3, Box 433—Lodi	49	1
Qualls, Edward G.	422 Palm Ave.—Whittier	26	2
Ramseier, Roy Edwin	619 Curtis St.—Berkeley	55	3
Ricket, James Robert	749 Belvedere St.—Pasadena	84	2
Robinson, Willis S.	152 E. Louise St.—Long Beach	18	2
Sanchis, Joseph M.	2341 Hillcrest Dr.—Los Angeles	53	2
Sauer, Victor W.	701 City Hall—Oakland	95	3
Schaller, John Edwin	159 W. 220th St.—Torrance	19	3
Seitel, G. C.	1511 Riverside Dr.—Chino	107	2
Shannon, Ronald C.	58 N. Roosevelt Ave.—Pasadena	81	2
Shaw, George	914 S. Tamarind St.—Compton	22	3
Shay, Lester J.	3439 E St.—San Bernardino	97	2
Shearer, Arthur B.	124 Tunstead Ave.—San Anselmo	4	2
Skeith, George S.	149 Norton Ave.—Long Beach	24	2
Skinner, William Victor	Box 22—Escondido	13	2
Smith, Alvin O.	1217 Cypress St.—Santa Ana	73	2
Smith, Frank E.	1100 East Broadway—Anaheim	74	2
Springstead, George H.	City Hall—Santa Clara	100	3
Steck, Vincent	1301 Harker Ave.—Palo Alto	47	3
Stewart, Jesse A	103 Main St.—Huntington Beach	76	2
Storms, James E.	1626 W. 146th St.—Gardena	17	2
Summers, William Francis	10728 Westminster Ave.—Palms	30	3
Tate, Charles R.	532 San Diego Ave.—El Cajon	32	2
Tennant, Carl F.	216A Park Ave.—Long Beach	8	1
Thews, Vernon William	814 Hawaiian Ave.—Wilmington	35	2
Thomas, Roy N.	131—14th St.—Seal Beach	60	3
Tierney, Thomas W.	2517 Lemon Ave.—Arcadia	88	2
Van Norman, James Howe	9900 Vista Del Mar—El Segundo	16	1
Wagner, Joseph William	3517 Milton—Pasadena	89	2
Weber, George E.	CityHall—Newport Beach	68	2
Welch, Joseph C.	Box 501—Ojai	3	2
West, Ezra Elwood	308 N. 10th St.—Colton	70	2
West, Fred A.	422 E. Jackson St.—Stockton	5	2
White, Russel C.	Yosemite National Park	9	1
Willette, Calvin R.	Yosemite National Park	62	1
Woodward, Robert Dee	463 Myrtle St.—Laguna Beach	51	2
Wright, Lee Roy	1169 W. 163rd St.—Gardena	44	2

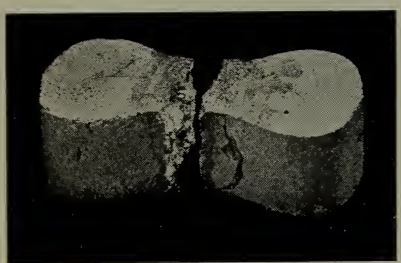
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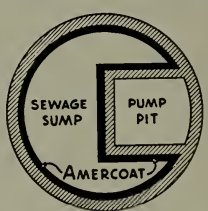
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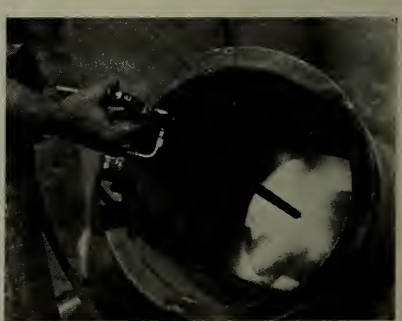


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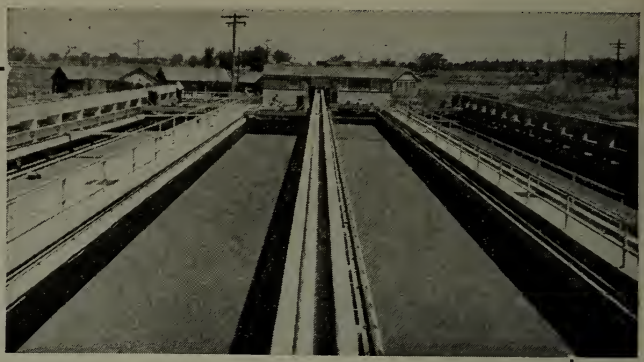
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Official Publication of the California Sewage Works Association

Vol. X :: 1938 :: No. 2

Minutes of the Tenth Annual Spring Conference
at San Diego, California
April 11 and 12, 1938

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Operator's Forum

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Symposium on Experiences with Paints

•

Electrolytic Corrosion

•

Ward's Island Treatment Plant

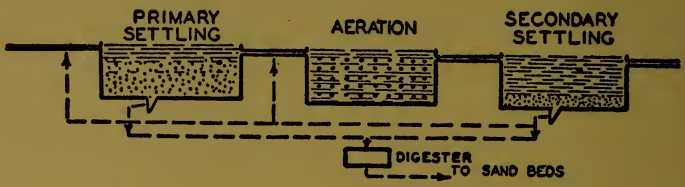
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San Diego Sewerage Problems

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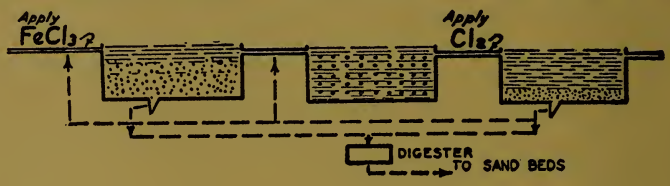
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The California Sewage Works Association is not responsible, as a body, for the supposed facts and opinions advanced in any of the papers, discussions, or articles published in this Journal. Discussion of all papers is invited.

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TENTH ANNUAL SPRING CONFERENCE

San Diego, Calif., April 11-12, 1938

PROGRAM

SUNDAY, APRIL 10

Afternoon

2:30—Registration—U. S. Grant Hotel.
6:00—Reception.

MONDAY, APRIL 11

Morning

7:30—Directors breakfast.
9:00—Business meeting and committee reports.
9:30—Operator's Forum.
"Operation of the Laguna Beach Plant to Control Odors," by R. D. Woodward, Operator and Mechanic, Laguna Beach.
"Operation of Huntington Beach Plant to Control Oil," by John C. Clark, Chief Operator, Huntington Beach.
Symposium on Experiences with Paints—
J. H. Van Norman, Operator, Hyperion Plant, Los Angeles.
Carl Tennant, Supt. of Operation Los Angeles County Sanitation District Treatment Plant.
Joseph Corrao, Supt. of Pumping Plants, City of San Francisco.

Luncheon

12:00—Date Room.
Address of Welcome by R. W. Flack, City Manager, San Diego.
"Special Message from Old Mexico," by Manuel Antillon, City Engineer, Tijuana, Mexico.

Afternoon

2:00—Technical Papers
"Electrolytic Corrosion," by Richard Pomeroy, Chemist, Los Angeles County Sanitation District.
"Ward's Island Treatment Plant in Pictures," by C. G. Gillespie, Chief, Bureau of Sanitary Engineering, State of California, and C. C. Kennedy, Consulting Sanitary Engineer, San Francisco.
"Metallizing, Coatings of Non-Corroding Metals," by L. E. Kunkler, President, Metallizing Co., of America.

Evening

6:30—Dinner—Plata Real.
8:00—"California Sewage Works Association Conference in Review" (Motion Pictures) by A. M. Rawn, Asst. Chief Engineer, Los Angeles County Sanitation District.
8:30—"Historical Water Development in San Diego County," by Col. Ed. Fletcher, Senator, San Diego County.

TUESDAY. APRIL 12

Morning

8:00—Harbor trip visiting San Diego outfall sewers. Guests of San Diego Harbor Department.
"San Diego Sewer Problems," by Fred Rhodes, Director of Public Works, San Diego.
"Plans on Future Sewage Disposal of San Diego," by B. D. Phelps, Asst. City Engineer, San Diego.

Luncheon

11:45—At George's Place, Carlsbad.

Afternoon

1:00—Leave George's Place.
2:15—Laguna Beach—Activated sludge plant.
3:00—Newport Beach—Separate sludge gas engine digestion plant.
3:30—Huntington Beach—Separate sludge digestion plant.
4:10—Seal Beach—Separate sludge digestion plant.
5:30—Arrive Los Angeles.

ANNOUNCEMENT OF THE FALL CONVENTION CALIFORNIA SEWAGE WORKS ASSOCIATION SANTA BARBARA, CALIFORNIA SEPTEMBER 6-7, 1938

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FIRST DAY—SEPTEMBER 6

The morning of September 6 will be given to a discussion of pumps used in sewage treatment works. In the afternoon the following three subjects will be discussed: "Remodeling of Old Plants," "Sludge for Fertilizer" and "Control of Chlorination."

The dinner meeting will be held in the evening and a good speaker is promised for the occasion.

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SECOND DAY—SEPTEMBER 7

The morning of September 7 will be a joint session with the Engineers Section of the League. Three papers of interest to both groups are being arranged and include "Patents in Sewage Disposal Works," "Legal Aspects of Sewer Rental Laws" and "Disposal of Water from Cooling Systems."

A short caravan to visit Ojai, Ventura, and Camarillo will conclude the Eleventh Annual Convention of the Association.

MINUTES OF MEETING
TENTH ANNUAL SPRING CONFERENCE
CALIFORNIA SEWAGE WORKS ASSOCIATION
at the
U. S. GRANT HOTEL

San Diego, California **April 11-12, 1938**

The tenth annual spring conference of the California Sewage Works Association convened on the morning of April 11, following a new innovation, an informal reception on the preceding evening. The reception was the occasion of a most enjoyable social evening and was well attended.

The meeting was called to order by President Ray L. Goudey promptly at 9:00 o'clock with a call for committee reports.

Chairman Fred Bowlus reported verbally for the Membership Committee, saying at this early date the Association has a paid membership of 200. We regret, however, that there is an annual membership turnover of 35 and will do all we can to reduce this number.

Sub-Committeeman Ben Benas reported verbally for Chairman of Schools Committee Harold F. Gray, saying that both Stanford University and the University of California had shown fine cooperation, insuring that the short School for Operators would be held and that within a short time an interesting and instructive program would be announced.

The Finance Committee was represented by its Chairman, J. F. Smith, who reported that sufficient advertising space had been sold to about pay for publication of the two Journals.

Due to a change in procedure, the Award Committee reports at the Fall Convention, instead of the Spring Conference.

The Legislative and Publicity Committees submitted written reports and reference is made to them elsewhere in the Journal.

All committee reports were accepted and the committees commended for their fine work.

In accordance with a motion made and carried, a telegram was sent Governor Frank E. Merriam memorializing his action in giving sanitation priority in the expenditure of State relief funds.

Interesting operating problems were discussed by R. D. Woodward and J. C. Clark, operators at Laguna Beach and Huntington Beach, respectively. A most interesting discussion on paints, lead by J. H. Van Norman, operator, Hyperion; Carl Tennant, superintendent of operations, Los Angeles Sanitation District, and Joseph Corrao, superintendent of Pumping Plants, San Francisco, was prematurely closed by the necessity for noon adjournment.

A count at this session revealed 110 in attendance.

Immediately following the noon luncheon, the Association was welcomed to San Diego by Councilman John Siebert, who generously offered the City's hospitality. The words of Julio Davilla, formerly city engineer of Tijuana, at present agent of the Department of Agriculture, Mexico, our luncheon speaker, will not be soon forgotten for his enthusiasm and the pledged friendship of his country. It is regrettable that his talk, presented extemporaneously, was not recorded.

Richard Pomeroy, chemist, Los Angeles County Sanitation Districts, opened the afternoon session with the presentation of a paper on "Electrolytic Corrosion." Several pieces of metal were exhibited as samples of this type of corrosion.

L. E. Kunkler, president, Metallizing Co. of America, formally introduced a new process to the sewage treatment field, and while it was not possible for him to give examples of "Coatings of Non-Corroding Metals" in sewage treatment, he explained their use in water works and other fields.

C. C. Kennedy and C. G. Gillespie brought the New York City Ward's Island treatment plant to us in word and lantern pictures. The tremendous size of this plant is indicative of the problems being and to be met as a result of the concentration of population in great eastern cities.

Adjournment was at 5:15 P.M.

The dinner meeting followed a long day of technical sessions and ordinarily after a fine dinner, interspersed with musical selections, dozing would have been in order. However, the contrary was the case when Col. Ed. Fletcher, a dynamic speaker, presented a short history of San Diego County in which he gave credit to several of our members. Then, A. M. Rawn presented moving pictures he had taken at previous conventions, interspersed with little witticisms, with which A. M. is gifted, to keep the group alert until nearly 10:00 o'clock.

On Tuesday morning the Association was the guest of the City of San Diego on a boat ride upon San Diego Harbor. During the trip Fred Rhodes, director of Public Works, addressed the group on the "San Diego Sewer Problems," and B. D. Phelps, assistant city engineer, told of the "Future Sewage Disposal Plans."

The group assembled twenty-five miles northerly of San Diego at George's Place for lunch and to hear Frank W. Herring, executive director, American Public Works Association, speak extemporaneously on "How Sewage Works Operators Fit into a Public Works Program." Mr. Herring's message was one of interest and encouragement.

After lunch a caravan was formed and the sewage treatment plants at Laguna Beach, Newport Beach, Huntington Beach and Seal Beach were visited. The caravan was disbanded at Seal Beach, leaving to choice the return route.

The registration of members and guests totaled 149.

R. R. RIBAL, Secretary-Treasurer

REPORT OF PUBLICITY COMMITTEE

April, 1938

The work of the Publicity Committee this year to date has been largely preparatory and analytical. The committee feels that the "shot gun" type of publicity will be of little advantage; directed publicity requires the study which has been given to date. Several excellent suggestions have been received by the committee and will be followed in the coming few months. One of them is an endeavor to secure publicity in local newspapers regarding certified operators in the community and, incidentally, regarding the aims and activities of the Association. Copies of this publicity will be directed to the mayors and councilmen of the respective communities.

Consideration has been given to ways and means of forming contacts which would make for closer co-operation with the various Fish & Game Associations which are most interested in elimination of stream pollution.

The committee would like to point out that through already set up procedure and association membership, good publicity is afforded in such magazines as *Western City, Western Construction News, Water Works & Sewerage,* and, in the future, *Municipal Sanitation.*

In order to give the committee a better picture of the existing and potential membership and interest in the C.S.W.A., Mr. Ben Benas has prepared a spot map which, in our opinion, contains sufficient information of interest to the entire membership of the Association to justify a few minutes for its presentation at the Spring Conference. Mr. Benas has therefore been requested to present a brief discussion of this spot map as a part of this report.

The chairman is very appreciative of the assistance received from Mr. Benas, Mr. Earl M. Kelly, and Mr. John F. Skinner, members of the committee.

A. C. BYER, Chairman

PROGRESS REPORT OF THE LEGISLATIVE COMMITTEE

April, 1938

Three legislative questions have been reviewed in some detail by the Legislative Committee. They are considered in this progress report in the following order: (1) Sewer Revenue Legislative. (2) The Vinson Barkley Bill, and (3) Expansion of the California Public Health Act.

Sewer Revenue Legislation

Attempts to enact sewer revenue legislation in the California Legislature have met with the following fates: Assembly Bill 980 introduced in 1933, failed of passage in the legislature. Discussion of the

bill and such publicity as it received developed some needful changes in the measure, however, and its general provisions were revised and reintroduced in 1935 as Assembly Bill 825. Both houses of the legislature passed Assembly Bill 825 but it was not signed by the Governor and therefore failed of enactment. In 1937 the bill was reintroduced as Senate Bill 966, a measure almost identical in structure with the 1935 bill, the principal difference being the elimination of a requirement to the effect that revenue bonds be marketed solely with the fiscal agent of the United States Government. This bill passed both Houses, carried the endorsement of the League of California Municipalities, the Los Angeles Chamber of Commerce, California Sewage Works Association and a number of other groups, but the Governor likewise refused to sign this measure and it therefore failed of enactment.

Opinions vary as to the merits of sewer revenue legislation. The California Sewage Works Association has consistently supported such a law, insisting that it is beneficial, fair and economical and that it will provide sewers in many instances where they are greatly needed and cannot otherwise be installed under present enabling acts. It has been stated that specific revenue legislation is unnecessary in cities other than those of the fifth and sixth class; that all other California cities are now endowed with sufficient authority to proceed with sewer rental measures if they desire to do so. This being the case, it would certainly seem beneficial to endow cities of the fifth and sixth class with power to proceed to construct sewers on a revenue or rental basis and to provide for all an act which will furnish a general method of procedure in all cases.

It is the recommendation of this Committee that the California Sewage Works Association continue its support of sound sewer revenue legislation; that it foster the introduction and passage of a Sewer Revenue Act at the next regular session of the Legislature; that it authorize its Board of Directors to act as a committee to interpret and explain the provisions relating to sewer rental and revenue and to give such information as wide publicity as the Association's publication outlets provide.

The Vinson Barkley Bill

This is a proposed measure which is designed to create a new division of the Surgeon General's United States Department of Public Health, known as the Division of Water Pollution Control, its objective being to provide ways and means for eliminating and reducing the pollution and improving the sanitary condition of navigable waters of the United States and streams tributary thereto. The new division may prepare comprehensive plans for eliminating or reducing pollution alone or in cooperation with municipalities or industries and with the help of the Chief of Engineers of the War Department; may encourage cooperative activities between the several States for the prevention and abatement of water pollution; encourage the enactment of uniform

State laws relating thereto; and, in general, assist State agencies in its objective. The bill provides that two or more States may enter into agreements or compacts for prevention or abatement of water pollution and for the establishment of joint agencies between the States.

The Division may conduct investigations and make surveys of specific problems in water pollution confronting States or their subdivisions and may, through the Public Health Service, prepare and publish reports of such surveys, studies and investigations. The Act declares that any public body now wasting untreated or inadequately treated sewage into the navigable waters of the United States is eligible for Federal aid or grants-in-aid or loans for construction of sewerage works, up to 33 1/3% of the cost of labor and materials employed in the project. The same assistance is extended to any individual under the same terms. The Act provides not only for the structure of the new Division, but instructs it to classify the navigable waters of the United States into sanitary water districts and, among other things, to fix standards of purity in each district for the navigable waters.

Section 8 of the measure provides, among other features, the following:

> "Congress hereby declares the discharge or deposit of any waste, . . . etc., into any of the navigable waters of the United States or into any tributary from which the same may flow into such navigable waters, if such waste be injurious to human health or any form of life, including aquatic life or migratory birds, would be against the public policy of the United States and would be a public and common nuisance. After the expiration of three years after the date of enactment of this Act, an action to prevent or abate any such nuisance may be brought in the name of the United States by any United States attorney. Such action shall be brought as an action in equity . . . etc."

The Board of Direction of the American Society of Civil Engineers voted on Feb. 3, 1936, "That for the present no further extension of Federal control over streams is desirable; that the Federal Government should restrict its activities in this field to the functions of fact finding and coordination and substantiation of State and interstate programs, and that initiation, administration and financing of projects should be reserved for State and interstate action." Following this action the Sanitation Engineering Division of the American Society of Civil Engineers discussed Section 8 of the Vinson Barkley Bill on January 20, 1938, and resolved itself as opposed to Section 8 of H.R.2711 of the 75th Congress—which is the Vinson Barkley Bill.

Consideration of the measure by your Committee leads them to the same conclusion as that attained by the American Society of Civil Engineers, Sanitary Division; namely, that Section 8 of the Vinson Barkley Bill endows the Central Government with more power than is required for the enforcement of the Act and that the Federal Government had best leave the initiation of projects to the several States,

assisting to the extent of investigating, coordinating and helping in interstate compacts. It therefore recommends that California Sewage Works Association go on record as approving of the Vinson Barkley Bill with the exception of Section 8 thereof.

Incidentally, the original bill was passed by the House on April 21, 1937, amended and passed by the Senate August 16, 1937 and has remained in House conference ever since, no further action having been taken to date.

Expansion of the California Public Health Act

During the last legislature Assembly Bill 2676 was introduced by Mr. Patterson. This was entitled "An Act to Prevent the Pollution of Rivers . . . etc.," and gave the State Board of Health power to enforce the provisions of the Act. Discussion of the measure by the Board of the California Sewage Works Association disclosed that in the opinion of the Board, the Act was improperly drawn and that State-wide sanitation would be better served by making minor amendments to the Public Health Act; in substance, by broadening the Public Health Act into a Public Health and Welfare Act. A change in the law of this order has the endorsement of Mr. C. G. Gillespie, Chief of the Division of Sanitation, Bureau of Sanitary Engineering, and will, in his opinion, meet the requirements needful to promote good sanitation within the State's boundary.

The Committee has no recommendation to make at this time but requests that it be allowed to continue to consider changes in the Public Health Act and report more specifically upon this measure at the fall meeting of the Association. Should the Vinson Barkley Bill become a law, it may be that complete revision of the Public Health Act will be in order. Should it fail to become a law, it is entirely likely that the expansion of the present Act to cover questions of public welfare will, as Mr. Gillespie indicates, be entirely sufficient.

A. M. RAWN, Chairman

R. L. Loucks

The recent death of R. L. Loucks marked the close of a veteran career in the sewage works field in Southern California. Mr. Loucks was an old time employee of the City of Santa Ana, serving as Assistant City Engineer, during which time he designed the sewer systems of Santa Ana, Garden Grove, Placentia, as well as the main outfall sewer for the City of Santa Ana and the joint outfall sewer to the ocean. Subsequent to his employment in Santa Ana, Mr. Loucks became City Engineer at Oceanside, redesigned the sewer system there and built the present covered septic tank and ocean outfall. In recent years, because of poor health, he had retired and was living at Riverside.

Fred V. Hammerly

Accidental death recently took from our midst Fred Valentine Hammerly an illustrious and active worker in the water supply and sewage works field. Born of German parentage in Tulare, California in 1887, graduated University of California Class of 1911, he was employed by the Geological Division of the Southern Pacific Company until 1913 when he joined the Water Works Supply Company becoming Vice-President of the Company in 1922. Specializing in sanitary engineering he developed special gauges in water treatment, areation of sewage by air taken in on the suction side of a centrifugal pump, was an advocate of new sewer jointing materials and an authority on flow measuring devices. Because of his inventive genius and his fundamental knowledge of chemistry he was an outstanding member of the sanitary engineering profession.

LAGUNA BEACH DISPOSAL PLANT WITH REFERENCE TO THE CONTROL OF ODORS

By R. D. WOODWARD*

The Laguna Beach Sewage Disposal Plant is an enclosed plant located within the City Limits, 5 blocks from the business district. It is an activated sludge system, equipped with:

One primary clarifier, 30,000 gal., with Hardinge equipment and Currie Air Skimmer.

Two secondary clarifiers, Hardinge, 33,500 gal. each.

Five Hardinge Aerators, with independent motors, tank capacity 51,000 gal. each.

One digester with circulating pump and hot water coils.

One gas furnace, gas storage tank, one outside burner.

Two Chicago pumps from the clarifiers.

One Chicago Screw feed sludge pump.

One chlorination pump, used as air clarifier to ventilating system.

Capacity of plant, 720,000 gal. per day. Total flow for 1937, 34,472,000 gal. Average per day 94,444 gal. Chlorine used for year 1937, 4,604 lb. Daily average, 12-¾ lb.

Our plant and trunk sewers were built at the same time. Lateral sewers were built later. Therefore, our plant was started with a very small flow, which was taken care of by settling, chlorination and ventilation. We were not able to start aeration until the flow reached 30 to 40 thousand gallons per day, as checked by a weir, and Morey & Jones flow meter.

Plant Ventilation.

The plant is ventilated by a large blower driven by a 3 hp. motor running continuously, which exhausts stale air from one end of each room and draws in the fresh air through ventilators at the other end. The ventilators can be regulated to draw more air from places where the odors are strongest. The foul air passes through a 20-in. pipe to a large chimney or ventilator tower placed on the hillside above the plant. The air is clarified as it passes through the pipe by 16 chlorinated water sprays. We have found this system to work very well. We never allow any stale sewage to stand in tanks or flumes. To hold odors down tanks and flumes should be kept clean at all times.

Plant Construction.

The plant has steel sash windows, light steel ventilators, stamped steel light fixtures. Some of the light fixtures and ventilators have been replaced and will have to replace more. I believe these items should be constructed especially for a sewage disposal plant of non-corroding materials. I am trying porcelain light fixtures and Everdur metal on

*Operator and mechanic, Laguna Beach, Calif.

one ventilator which cost very little more than the original units. One other problem we have met is that no provision was made in the plant for a shop or storage of supplies. Although we have built two cabinets and bench, these do not take the place of a shop. Every plant should have a shop. We hope to get one soon.

Hardinge Aerators

These aerators are inverted pumps, which force the water from the middle of the tank to the bottom through 48 small nozzles. As the water passes the suction point in the pump, by siphon action it takes in air distributing it in the water. At first the nozzles were pointing to the wall and upward. This arrangement allowed the air to pass out of the water too quickly. The nozzles were then tried pointing across the tank, which arrangement holds the air in suspension much longer. Now, I have lengthened every other pipe or discharge nozzle of the aerators to 3 feet, which gives still better circulation and air distribution, and allows finer adjustments, increasing the efficiency.

Gas Furnace

In order not to spoil the beauty of the building, a long vent pipe or chimney was used over the furnace, and has given lots of trouble from condensation running into the furnace and clogging it up, as well as running out onto the floor. We have had to clean our furnace three times, the last time discovering the vent pipe completely corroded. In order not to spoil the looks of the building, the long vent was replaced with J. M. Transite pipe doped inside with Inertol, with a trap provided to catch condensation. It is my belief a straight vent through the roof allowing the gas to go out hotter would have been better.

Pumping Plants

All our pumps are Chicago nonclog, driven by hollow shaft U.S. motors with the line shaft hanging on the motor bearings. This support for the shaft is not very satisfactory. Every time it becomes necessary to remove a shaft, you lose the lineup. There being only one universal joint, the motor has to be moved to get the shaft out. With two universal joints this would not be necessary. We have a great deal of moisture and sometimes a flooded pump, usually caused by sticky check valves. All our line shafts are ball bearing. Ball bearings running in water give lots of trouble. Most all ball bearing greases will not withstand submersion in water, so I tested grease in the following manner: I made a beater for a small electric drill, placed a ½ lb. of grease in a can with a cup of water and beat it for fifteen minutes. If the water will pour off the grease after this, it will hold in the bearing in water. So far, only two kinds of grease have been found that will stand this test.

Sand gave trouble in one of the pumping plants and resulted in the flooding of the pump and motors. The motors were taken apart, dried out by use of a large air compressor, reinstalled and these motors are still running. After removal of sand from the pumps, we found them so badly worn they would pump only about one-half their rated capacity

which was unsufficient to handle the sewage. New parts were not available. The first pump was taken out, the worn parts welded and machined. This pump is still running. On the second pump we discovered that by machining the lower pump body, we could make a plate instead of welding. The plate was made reversible. When worn, it can be turned over and used again. The worn runner was welded and machined. These pumps have now run a year and a half without further repairs. Not even repacking. We find these pumps should be very closely adjusted. The runner should be set as close to the suction plate as it will run, or about .005 clearance. If this is done, they will not clog.

All of our line shafts are mounted on steel beams, 3 or 4 ft. long across the wall of the pump room, which rooms are 8 ft. in diameter and from 15 to 28 ft. below ground surface. Being constructed in this way, the bearings are quite noisy. I have overcome some of the noise by mounting the bearings on rubber.

Future Improvements

Future improvements consist of a new main line connecting the old system to the plant, a new district main line and laterals; and initiation of laboratory control for the plant.

The grounds will be improved with lawns and graveled roadways. A sprinkler system using the effluent will be installed for watering. Some of the effluent may be used for the sprinkling of City Parks.

DISCUSSION

Mr. Fiscus: In referring to the Chicago non-clog pump, you say that it won't clog. Ours does clog. While I have found that adjustment helps a lot, I haven't made the clearance as close as you have. I will check operation on a closer adjustment.

Mr. Goudey: It is interesting to know that by a close adjustment (.005 clearance) Mr. Woodward has avoided clogging that bothers Mr. Fiscus.

Mr. Woodward: I might add that I have had a little trouble with my Chicago screw sludge pump due to a rock getting in and breaking a small piece out of the runner or screw which caused plenty of clogging. The runner or screw was welded and reinstalled to .005 clearance and has given no trouble since.

Mr. Fiscus: Have you tried pumping a sludge that is gaseous?

Mr. Woodward: Yes. Occasionally we have a little trouble with gas, but it is not bad at our plant.

Mr. Castro: I have had a good deal of trouble with clogging. When advised to set the cutting edges closer together by a representative of the pump company, I discovered the stellite edges badly damaged. It is very inconvenient to take the pump apart once a day and knock out sticks that have caught around it. The sludge pumps of newer design are provided with a clean-out where the sludge enters into the flight,

permitting easy access to eliminate trouble. Gas has also given considerable trouble.

Mr. Post: Why not install screens ahead of the pumps?

Mr. Woodward: Our plant is so arranged that very little rock, cans or other foreign matter gets in to give trouble.

Mr. Goudey: A subject for our next conference will be "Pumps."

OPERATION OF HUNTINGTON BEACH PLANT TO CONTROL OIL

By J. C. CLARK*

In the operation of the Huntington Beach sewage treatment plant my worst problem has been crude oil. We are fortunate in having a Dorr Co. Clarifier the skimming trough of which has a bypass to a concrete pit. To get rid of the oil and other materials bypassed to this pit is my problem. It costs about $40 a month to haul the oil away from the pit and dispose of it. I inquired of everyone I came in contact with as to how I might solve this problem and save the expense. No one seemed to know what to do. In discussing an idea of my own with the designer of our plant, he said he didn't think it would work. I seemed so down in the dumps over it he said he would give me a cigar if it did work. I don't care for cigars but I do want to get rid of the crude oil.

I have built a pit 3x9x2 ft. over an underground drain line with about 1 ft. of No. 2 rock in the bottom and about 8 in. of sharp sand on top to act as a filter. The idea of the filter is to dewater the oil. I covered the pit with a ½-in. iron plate about 2 ft. above the top of the sand. In one end I placed an 8-in. chimney and the other end is fixed for a gas burner. The idea is to confine the heat on this heavy oil and cause it to boil, vaporize and burn. If some of the oil runs into the sand it will be very easy to replace.

But now I come to the sad part of my experiment. On March 3, we had a flood, before I could prove my idea satisfactory. I have to tell you how my device works another time. As soon as the mud dries I will dig my burner pit out and fix it and try to burn some oil in it.

DISCUSSION

Mr. Currie: If any of you are familiar with the oil problem at Huntington Beach, you know that houses were moved from the western part of the city to permit drilling of oil wells upon the lots. The house sewers were then used to drain the oil sumps. Though for years an attempt has been made to eliminate these connections, some of them still exist. When the treatment plant was put in operation, there was at least 3 in. of oil on top of the clarifier. A sump and bypass for skimming was provided for use during the period when oil was present. At a considerable expense this material has been hauled away. In an attempt to burn the oil, it was found that the heat was not sufficient to keep the oil ignited. Consequently, the sand bed was built and a plate

*Chief Operator, Huntington Beach, Calif.

placed 5 or 6 in. over the burner, hoping the reflected heat would ignite the oil but when the oil became thin it would run into sand. I am still of the opinion this device will not work. The plant was flooded with 8 ft. of water so the device has not had a fair test.

Mr. Goudey: Could not the flooding of the plant have been saved by a storm wall or dike?

Mr. Currie: The plant was constructed on a low piece of City owned land within a drainage district. The pumps of the district were too small to handle the flow and were swamped.

It will be necessary to put the effluent of the plant onto the soil for some time to leach out the alkali before trees and plants may be set out. It is hoped that eventually alfalfa and other crops may be raised.

Mr. Parkes: A portion of Wilmington has recently become an oil field and I presume residences have been moved leaving the house connections as a convenient place to drain oil sumps. We, therefore, have somewhat the same problem at the Terminal Island Treatment plant. On a few occasions, our plant was almost put out of commission by inflows of a heavy black oil that will not burn, unless intense heat is put to it, either because of not being volatile enough or because considerable amounts of water are emulsified with it. In one or two cases we have found the source and eliminated it. The United States Coast Guard is now charged with harbor pollution matters and cooperates with the State Fish and Game Commissions. I think I am right in the manner in which one case was handled. The source from which the oil entered the sewer was discovered. The oil company was charged with violation of law and given the option of either pleading guilty to the State law carrying a fine of $240, or not guilty to the Federal law providing a fine of $2400. The oil company pleaded guilty to the State law. If we can locate other sources we will stop them the same way. Some of the oil companies pay little attention to city or state officials, but action by the Federal government will often get results.

Mr. Currie: We can get the oil out of the Huntington Beach plant, but the problem is to dispose of it after we get it out. There is not much water in the oil. It is almost asphalt.

Mr. Allen: In former years we have had considerable trouble with oil. I am inclined to believe with Mr. Parkes that the violator should pay for the damage done. We always present a bill. The source of oil may be run down by inspection at manholes. Some years ago we presented a laundry with a bill for $70 and thereafter they became oil conscious. In every instance when we have found the source of the oil we have been able to stop it by presenting a bill. The three cities served by our plant work with us. A very close check by our building department has reduced our oil problems.

Mr. Fiscus: I would like to add to Mr. Parkes' statements. Commander Nelson came to see us when we were having oil trouble and suggested that we take a sample of the oil and then bypass both oil and sewage into the ocean. After that they said they would attend to the matter for us.

EXPERIENCES WITH PAINTS

By J. H. VAN NORMAN*

Surface coatings composed of coal tar pitches have long been used to resist corrosion on metal surfaces. They were originally developed over forty years ago to protect metal on shipboard against the corrosion of salt water and against the corrosive gases formed in the bilges of boats. Since that time, they have been applied to many fields—the interior of tanks for the storage of drinking water, the interior and exterior of steel and cast iron pipe, in acid tanks, brine tanks, concrete tanks and reservoirs, bridges, steel piling—in fact in any place where problems of corrosion of metal had to be conquered. One of the most important uses to which these enamels have been placed is the protection of pipes and machinery in sewage disposal systems.

Coal tar enamels owe their ability to resist and prevent corrosion to the fact that they are, after application, completely homogenous masses; and while they look very like ordinary asphalt in appearance, they are greatly superior to this latter material in their resistance to corrosive agencies. Asphalt, when viewed under a microscope, presents a crystaline structure and is, therefore, porous, permitting the transmission of both moisture and gas while, as we have said, coal tar pitches are entirely homogenous in structure and, therefore, non-porous; neither moisture nor gas can penetrate them.

Until comparatively recent years coal tar enamels have had certain physical defects which made their use difficult in some applications. These defects were brittleness at low temperatures and the tendency to run or sag at higher temperatures. Within recent years, as a result of extensive research on the components of coal tar pitches, these difficulties have been overcome.

Coal tar enamels must be applied hot over a special coal tar primer by means of what is known as a Tampico Dauber. Solutions of coal tar pitches are also available but these are not as efficient as the hot application enamels in resisting corrosion.

While these coal tar enamels are highly satisfactory in their ability to resist corrosion, quite often in the buildings of sewage disposal plants it is desirable to use an enamel which is decorative. This enamel must, of course, resist the gases, especially the hydrogen sulphide, so prevalent around these plants. For that reason it is impossible to use a paint containing lead where a white or light color is desirable since white lead, basic lead carbonate, coming in contact with hydrogen sulphide turns to black lead sulphide. For this reason to be suitable for this purpose an enamel must be made using zinc oxide or zinc sulphide as a pigment. Both zinc oxide and zinc sulphide are white in color. Zinc oxide coming in contact with hydrogen sulphide forms zinc sulphide and, therefore, no discoloration results. Paints which have the ability to withstand hydrogen sulphide fumes are called "non-bilging paints." The term is derived from the fact that when lead paints were used on

*Operator, Hyperion Plant, Los Angeles, Calif.

shipboard, they were blackened by the hydrogen sulphide, resulting from the decaying organic matter in the bilges of the boat, and when they would so darken were said to "bilge." A paint which would withstand this darkening action was spoken of as a "non-bilging paint." The term has been adopted generally to distinguish paints possessed of this quality.

PAINT POINTERS

By CARL F. TENNANT*

Paint and its application as concerns the sewage treatment plant operator confines itself to the simpler classes of work and the use of ready-mixed paint. It requires no great amount of artistic ability to keep a treatment plant tidy. The more that is known about the behavior and qualities of different paints the more intelligently the operator can purchase the material best suited for the work at hand.

Because a material may possess outstanding qualities for one class of work does not signify that it is suitable for all classes of work. For instance, linseed oil is an excellent outside protection but when used inside turns yellow. And white lead may be used with great success in house painting but cannot be used at the treatment plant because of the corrosive action of sulphide gases upon it.

In ordinary paint there is no chemical action between the vehicle oil and the pigment. The pigment is suspended within the oxidizable oil and gives the paint body and wearing qualities but the set of the paint comes entirely from the absorption of oxygen by the oil.

The oils are classed as: drying, such as linseed and Chinawood oil; semi-drying, such as corn oil and soy bean oil; and non-drying, such as castor oil. Nearly all oils used in paint require processing to make them more suitable. Raw linseed oil is slow-drying but after heating the power of oxygen absorption is accelerated, raw Chinawood oil (tung) dries wrinkly, corn and soy bean oil must be processed to make them suitable and castor oil being a non-drying oil is used in very small amounts as a retarder for highly volatile vehicles. These and other vegetable oils are used by the paint manufacturer in varying combinations to procure just the right film, gloss and speed of drying. Nut oil and poppy seed oil are also used for inside work where white is desired, as is menhaden fish oil.

The thinner recommended by the paint manufacturer should always be used. In varnishes and enamels it is quite possible to use a thinner not compatible with the original mixture and, therefore, loss of time, waste of material and disappointment result.

Driers are admixtures to accelerate the oxidation of the vehicle oil and should be used very sparingly as they shorten the life of the paint film. Driers may be chemical in nature or specially processed oils. Japan

*Superintendent, Sewage Disposal, Los Angeles County Sanitation Districts.

drier is a resin drier used preferably in varnish but oil driers are considered superior in oil paint. Litharge is also a powerful drier.

The white pigments most commonly used are white lead, (lead carbonate) and zinc oxide. White lead, of course, is unsuitable for use where there may be sulphide gas as it will quickly corrode to a metallic blue-black or gray. Sublimed white lead is more resistant to the attack of sulphide. Zinc oxide if fairly pure is non-bilging but in most instances contains a little lead due to the ore impurities and cannot always be relied upon not to corrode. The addition of ten to twenty per cent of commercial zinc oxide to white lead helps to prevent the lead from chalking. Barium sulphate is also used as a white pigment.

Black pigments are graphite, lamp black and a long list of bituminous products ranging from albertite to ground coal. Black paint when used outside soon loses its luster and weathers badly. Some black paints will oxidize quickly, rubbing off as a black or brown powder. Black should be used only to a limited extent because it is very somber and gives the plant a dreary appearance. There are blacks on the market known as automotive enamels which retain their luster much longer than plain oil paints.

Aluminum paint is so well known that it needs no recommendation, but this paint has some peculiar characteristics and is so very often misused that a word about its behavior may be in order. To begin with the pigment or powder is not powder at all but tiny flakes or leaves. When the paint is applied these flakes adjust themselves in a compact scale formation presenting an aluminum sheet to the weather. The spreading of aluminum paint is more of a flowing process than that of brushing. Care must be taken to use only the proper amount of powder per gallon as recommended by the manufacturer. If too much powder is used the particles are crowded and do not have room for the proper leafing. Because the aluminum powder actually floats the proper vehicle must be used. The use of the wrong material may cause the powder to lose its buoyancy and, therefore, no leafing or adjustment will occur. After the paint has been spread evenly and the powder particles have adjusted themselves the paint should not be restroked. The paint should be stirred frequently and only a small amount mixed in advance. There are several types of aluminum paint on the market, some more brilliant than others.

Since in paint it is a matter of pigment dispersion in the vehicle oil rather than solubility, thorough mixing is very essential. A hand drill with a ¼-in. rod bent in a closely compressed letter S will save a great deal of time for initial mixing. Frequent stirring of the paint with a paddle while applying will give the surface a more uniform film. Thorough stroking both ways is necessary to obtain an even thickness of the paint film. This should be done with the tip of the brush.

Over new galvanized work a special primer should be used before paint is applied. Vinegar is sometimes used for this purpose but it may be more satisfactory to buy the special primer of correct strength. After the primer has been applied the surface must be allowed to dry

before paint is applied. For ungalvanized iron red lead has no close competitor as an efficient primer. Oxide of iron called barn red is sometimes used but red lead is generally accepted as being superior. The primer is the real life of the paint job and should be very carefully applied. The work must be clean and free from foreign substances or rust. If heavy rust is covered over, the corrosion will continue to progress slowly even under the paint film. In the priming of wood work the paint should be well thinned with turpentine to permit the first coat to soak into the pores of the wood. This provides a root for succeeding coats.

If the job is to be two or three coat work each coat should be slightly off color. If the job is let by contract this may insure getting what was paid for and if you do it yourself this method eliminates the chance of missing part of the work.

Bleeding is the softening of paint when applied over some material that prevents the paint from setting. You may recall having tried to paint over a piece of dipped pipe. Tar or creosote will cause bad cases of bleeding. The remedy is either the use of specially prepared stain killers or a coat of aluminum paint. Paint can then be applied in any color desired.

Peeling is either the result of a poor foundation being provided by the primer, a poor grade of paint or too thin an application. Three thin coats of paint are better than two thick ones.

Blistering is caused by moisture being trapped beneath the paint film or the paint being subjected to high temperature before the oil has set more than skin deep.

Since the oils used in paint are oxidizable and the oxidation of a substance creates heat, rags used in painting will heat to the point of ignition if left wadded. If the rags are to be used again spread them out so that the heat generated may be carried off by the air and no fire will occur.

The counsel of the representatives of reliable paint houses is always helpful and I wish to acknowledge their cooperation. I wish to extend special appreciation of the assistance of Messrs. Williams and Anderson of the General Paint Corporation. When in trouble consult a paint specialist.

EXPERIENCE WITH PAINTS AT THE MARINA SEWAGE PUMPING PLANT

By JOSEPH CORRAO*

Paints used for protection against the severe corrosive conditions in sewage plants are limited by the materials available. Research work is constantly carried on in the endeavor to develop new materials for this purpose. Several of the more progressive sanitary districts have made progress in solving this problem by carrying out experimental work in their chemical laboratories. In some cases complete specifications for paints with chemical formulae have been produced and are used as standards. The problems of painting can probably be best worked out by a closer combination of effort from the engineer, committees formed by engineering societies, and the manufacturer.

Due to the fact that the Marina Pumping Plant, located in the City of San Francisco, has been constructed entirely underground, certain problems of painting have been encountered which have caused considerable concern.

The structure is cylindrical, with a diameter of 55 ft., and extends to a depth of 30 ft. below the ground surface. The walls are 2 ft. thick, and the structure is divided into two main sections, one the dry well composing the pump room, and the other the wet well or sump. There is a separate entrance to each section from the ground level, but no connection exists between the two. The raw sewage enters the sump through a 30-in. main which is connected to the sewer by means of a drop down diversion structure. Due to the restrictions set by the Park Commission of the City of San Francisco and the fact that the plant is located in an exclusive residential district, the problem of ventilating presents several difficulties. The ventilation of the plant is accomplished by discharging the air from the machinery room through a grill located at the ground level, and the exhaust gases from the sump are discharged through a hollow stainless steel flag pole sixty feet high.

Initially, that part of the concrete walls of the sump submerged in the sewage was painted with a bituminous base paint, and that part of the walls not submerged was painted with mill white gloss enamel. The mechanical work such as piping, railings, and valves were painted with dulux machinery enamel. Within several weeks after the plant was put into operation, the mill white paint softened and turned dark brown. It would not harden, and as time went on, the condition became worse and finally the film spawled off of the wall. The coating would harden, however, during shut down periods, but with normal operations it would again soften, especially when the humidity and temperature were high.

The enamels used for painting the metals in some cases were applied with a prime coat of red lead followed by two coats of machinery

*Superintendent of Pumping Plants, City of San Francisco.

enamel. In some cases, the metal surfaces were merely given two coats of machinery enamel. The coatings in which the red lead prime coat was used failed within several months, but the coatings applied without the red lead prime coat lasted considerably longer, especially when the surfaces were thoroughly cleaned of mill scale and dirt before application.

The bituminous base paint used on the walls stood up with no apparent marks of failure. The original coating is still intact.

Our attention was immediately concentrated on the reasons for failure and the possible elimination of similar results elsewhere. With this in view, considerable experimenting has been done and a sincere effort made to thoroughly solve our problems. Samples of paints are being constantly analyzed by our City Chemist and are put to trial by placing them in the sump of the Marina Pumping Plant.

In discussing the subject of painting as applied to sewage works, it might be beneficial to consider a few fundamental characteristics of paint which will enable those not very familiar with the technical phase of the subject to better understand why they fail in certain conditions.

Pigment

Pigments constitute the body or aggregate of the paint. They are the major factor in determining the density and also the impermeability. The impermeability is sometimes accomplished by the formation of a hard interlocking surface which is formed by the pigment rising to the surface of the liquid before it hardens. Aluminum and mica perform in this manner.

Vehicles are protected by opaque pigments because they hinder the action of actinic light or sunlight.

Neutralizing decomposition products formed during the process of oxidation while drying and aging of the film takes place is another important function of the pigment.

Rust inhibition is accomplished by some pigments because of their passivity on the surface of the steels and thus prevent corrosion from taking place even though water and corrosive agents succeed in penetrating to the steel. This action stops, however, if the film is broken. The decorative features of coloring are largely brought about by the pigment.

Binding Material

That part of the vehicle which furnishes the binder, is composed of drying oils and natural or synthetic resins. The term vehicle as used in painting means the liquid medium with which other substances are mixed to form a binder for the pigments and also to permit easy application of the paint. The most important of the oils are linseed, tung, fish and soya. The oils assist in binding the particles of pigment together. This is accomplished by evapora-

tion, polymerization and oxidation which results in hardening of the film.

Linseed oil has been used extensively and dries in the film forming a leathery substance known as linoxyn. This oxidized film is fairly waterproof. Although a certain amount of water passes through this film, no serious effect takes place, especially if a passive pigment is used such as lead; but if the little bubbles formed by the moisture should burst, then rusting or corrosion takes place.

Linseed oil is generally refined by acid and alkali and heat treated to different degrees. The more heat treatment given, the more waterproof it becomes. The oil then is very viscous and hard to brush, but is more water resistant. The heating increases the reactivity of the oil so that when certain reactive pigments are used trouble will be experienced with hardening in the containers.
The heat treatment expels moisture and reduces the amount of oxygen needed for ultimate drying.

Tung oil (china wood oil) is also very commonly used. The oil is never used in a raw state. Tung oil varnish films are more waterproof than are linseed oil films. A combination of tung oil and linseed oil is often used.

Solvents and Thinners

Primarily, solvents and thinners are used to dilute the paint and render it less viscous, thus making it more easily applicable. The thinner is lost during the process of drying of the applied paint. When turpentine is used as a thinner it partially polymerizes and becomes an integral part of the dried paint film.
Some of the other things accomplished by solvents and thinners are:

1. Reduction in the consistency of the paint in order to permit proper application by brushing, spraying, dipping and enabling the application of flat finishes.
2. Forming a solvent for the gums, polymerized oils and the driers.
3. Formation of skin and wrinkle effects are greatly reduced.
4. Increases the bonding of films and their penetration.
5. Makes possible the use of highly pigmented paints.

In analyzing the failure of the mill white gloss enamel paint used at the Marina Pumping Plant it was found to be due to two causes, namely saponification and the reaction of the hydrogen sulfide gas with the lead pigments in the paint forming lead sulfide, which is yellow to dark brown in color, depending on the length of time of exposure.

Paints containing drying oils such as linseed, tung, fish and soya contain variable amounts of fatty acids which combine with the pigment and form compounds called soaps. Both soluble and insoluble soaps are formed.

In painting over concrete, plaster, and brickwork, soluble soaps of sodium, calcium, and potassium may be formed, thus destroying the

bonding effect of the paint if not properly controlled. This saponifying action took place quite extensively on the walls of the sump of the Marina Pumping Plant. This action was aided materially by the moisture in the concrete which was present due to the fact that the structure is underground and many months would be required before the concrete would be thoroughly dry.

The action due to the hydrogen sulfide will be described in the following paragraph.

The main causes for failure of paints in sewage plants are as follows:

1. Hydrogen sulfide gas and sulfuric acid
2. Grease and oil
3. Ammonia
4. Water
5. Organic life
6. Sunlight
7. Mill scale and mechanical damage
8. Improper cleaning of surface to be painted
9. Faulty application of paint

Hydrogen Sulfide

The reaction of hydrogen sulfide gas with lead pigment of the paint forms lead sulfide which is yellow to dark brown in color and destroys the decorative qualities. Where lead compounded paints are used in conjunction with other paints as top coats, the top coats will be discolored.

In analyzing the action of hydrogen sulfide gas, which is by far the most prevalent and difficult aggressor encountered in painting around sewage plants, several interesting facts will be found. Tests made in many laboratories indicate that hydrogen sulfide gas will pass through most of the dried films. Those using linseed oil as constituent cannot withstand the action of the gas, but the films using tung oil have been more successful in this respect.

Iron or steel painted in an atmosphere of hydrogen sulfide and high humidity are subject to another serious action. The moisture collecting on the surface of the steel work absorbs hydrogen sulfide. The sulfide is oxidized first to sulfurous and then sulfuric acid. Conditions are constantly changing in these atmospheres, and consequently these acids appear in varied concentrations. There are only a few paint films entirely impervious to their passage; therefore, the acids penetrate to the steel and react with it forming sulfur compounds of iron which may occur as black dust, or if moist, a black slime. As a consequence the film breaks down and the acid attacks the steel with increased effectiveness. The ultimate result is the complete breakdown of the surface painted.

The parts most readily effected are the lower part of frame openings, railings, and panels on doors.

Grease and Oil

These materials do not of themselves seriously affect the steel work about the plant but, as a matter of fact, protect it. However, when oil or grease becomes emulsified with water they very effectively destroy the paints they come in contact with. They dissolve the vehicle, soften the film and make it susceptible to mechanical damage thereby exposing the steel to attack by water, hydrogen sulfide, and other destructive agents.

When considering paints for metal work to be used under sewage this action must be seriously considered. The only type of paints that appear to resist this action are the highly resinated phenolic, and resin-tung oil varnish paints.

In general, paints which resist the oils and greases are not very effective against hydrogen sulfide. There are several new but rather expensive synthetic resins on the market which have proved reasonably successful.

Ammonia

Ammonia is formed in sewage works by the breakdown of proteins by organic life. If the sewage is fresh it may be present only in small quantities and its immediate action will not be serious, but over a long period of time it will destroy the paint subject to its action. The fact that it is of alkaline nature causes the saponification of the fatty acids of the vehicle and so destroy the binder of film. Caustic soda has the same effect.

Water

The most common of the destructive agencies is water. There are several ways in which the action of water performs its destructive functions.

When present on the surface before painting, it fills the pores and does not permit the paint applied to come in contact with the material, and therefore does not grip firmly. The vehicle becomes saturated and the other constituents become hydrolyzed causing swelling and loss of strength.

It permits oxygen, hydrogen sulfide, ammonia, and other substances to be conveyed into the film where they either destroy it or make it readily susceptible to damage.

Steel is damaged by this action when the pigments absorbed in passing through the film are electro positive to the steel and thus cause corrosion. However, some pigments when dissolved are inhibitors of corrosion and others have preventive action, but in these cases the prevention only lasts as long as the pigment is present and the action ceases when dissolved from the film. In the event that corrosion of the steel begins under the film, the adhesive qualities will be destroyed and blistering takes place. When the blisters, or nodules, become punctured there is nothing to interfere with direct action of the water and corrosive elements upon the steel and the action continues unhindered.

Sunlight

Sunlight combined with the presence of oxygen has an ultimate destructive effect on paints. The process of oxidation is increased in the presence of sunlight. The major phases that take place in drying of paint are (1) the solvent and thinners first evaporate leaving a soft coating, (2) oils then become oxidized to form a hard, somewhat elastic film which oxidizes away as time progresses, and (3) organic compounds become polymerized causing structural changes. In the second step the presence of oxygen is absolutely necessary. The action of sunlight also assists in this phase. Sunlight alone has the predominating influence on the third step; oxygen has no contributing influence.

The evidence of disintegration by sunlight and oxygen is shown by chalking and cracking of the film. These effects are caused by changes in film structure so that the elastic and cementing qualities disappear.

Organic Life

Some direct effect is caused by organic life, but in temperate climates it can be neglected. The action takes place on the vehicle of the paint. In tropical climates, however, this would cause considerable trouble because the moulds found in these climates are destructive. The serious indirect effect caused by moulds are those which must be considered. The formation of hydrogen sulfide and ammonia as by products of organic life is the indirect means that causes destruction because of the oxidation of hydrogen sulfide into sulfurous and sulfuric acids.

Mechanical Damage and Mill Scale

Mechanical damage due to flotsam in the sewage or abrasion during application of the paint are the most common forms.

The action of peeling of the surface due to mill scale may also be considered in conjunction with this subject. This is a very troublesome cause and considerable study has been given as to possible cures.

As steel lays hot on the cooling tables of the mill, oxygen is absorbed and a number of oxides of iron are formed. This coating is very thin and adheres strongly to the steel. This initial coating cannot easily be removed by wire brushing or scraping. Special means must be used in order to remove this scale. If this scale remains unbroken in fabrication or handling, it acts as an excellent protection, but in practice this very seldom exists. The scale is generally cracked and loosened over variable areas. Sewage containing ionizing salts or moisture containing acidulous gases coming in contact with this heterogeneous surface causes it to become loose, and eventually it falls off in flakes. If the surface of the scale were painted it would likewise fall off with the scale.

However, if the cracking of the scale was not serious enough to rupture the paint film the corrosion effect would be inhibited, but with the event of breaking of the film the corrosion will start, causing the result previously described.

The corrosion causes the red, brown, and yellow oxides, hydroxides, carbonates of iron, all of which are readily visible and which appear

to be the cause for the failure, but in reality the original black oxide is the cause and is difficult to find.

The relatively thin scales which are formed when rolling steel has been done at low temperatures are more difficult to remove than the thicker ones which are produced by rolling at high temperatures. The fact that modern steels are rolled at higher temperatures than in former years is the reason for the increase in paint failures due to mill scales.

Experiences with weathering steel before painting have proved decidedly unsatisfactory. Although some of the scale may be removed by this process, other disadvantages which occur due to long periods of exposure to weather conditions defeat the practicability of its use. Also the chemical effects on the paint applied after the weathering process generally are injurious.

The method of coating the surface of steel with phosphoric acid washes commonly known and sold as inhibitors, has met with success in some plants. Although this method has not been used extensively, reports of its use elsewhere seem worthy of further consideration. The action when applied to steel appears to bring it into a passive condition reducing the danger of rust formation and insuring good adhesion of the paint. This method of preparing the surface can be done by applying the solution with a brush, making it practical to use in the field. Care must be taken when using these solutions not to select a paint that will be seriously effected by the phosphor compounds formed at the surface of the steel.

Parkerizing and Bonderizing are other methods used in which phosphoric acid is used. In these cases the metals are given a much more extensive treatment than with the previously mentioned method. The pieces to be treated are dipped in tanks containing the solution. However, the cost of this type of treatment is expensive. The size of the pieces treated is also limited by the size of tanks and facilities available for handling. This method, therefore, can only be used in special cases.

Wire brushing and scraping cause the mill scale to be broken and loosened from the steel. This results in a heterogeneous surface with unsatisfactory conditions for painting, and causes a premature failure.

In preparing steel for painting the best treatment available at present is the complete removal of scale by sand blasting or shot blasting. The prime coat should then be immediately applied while the surface is clean and dry.

Improper Cleaning and Faulty Application

Improper cleaning of surface before application, adding too much thinner to the paint and applying too thin a coat as the prime coat, allows destructive agents to readily attack the surface painted.

The general precautions which are very commonly known come under this heading and consequently will not be considered in detail.

The difficulty encountered with cement paints is the discoloration. This is due to the soluble lime salts which are formed in setting off the

cement. The paints used at the Marina Pumping Plant were supposed to contain a compound which would reduce this ratio of soluble salts as they formed and thus prevent serious discoloration. However, the theoretical results have not been obtained, and there is considerable change in colors which vary according to the moisture content on the surface.

Conclusions

In the light of the experiences gained at the Marina Pumping Plant and the results being constantly obtained by experimentation, certain limited recommendations are now possible. The experimentation carried on to date has not been of sufficient duration to warrant recommendation of specific formulae, but the characteristics and results of certain classes of paints used have proved that they are well qualified for certain types of work. It must be remembered, however, that when considering the use of paints that conditions affecting corrosion of metals vary considerably in different localities, and therefore every precaution should be taken to select protective coatings which are designed to meet the conditions in question.

1. **Concrete walls exposed to sewage and gases (No sunlight)**
 Bituminous base type of coatings are far more successful than other types. The concrete surfaces must be cleaned thoroughly, and all traces of paint remover when used must be washed thoroughly. Surfaces must be dry before application.

2. **Iron and steel submerged in raw sewage or exposed to gas**
 The actions of metals below the surface, especially where the body is moving, is not so severe as might be expected. The greatest difficulty in maintaining the paint on the metal is due to the action of grit and flotsam in the sewage. The metal may even be brightened by the scouring action. Because of the oxygen demand of the sewage this action is probably minimized. Bituminous enamels fortified with high grade synthetic resins have produced favorable results. Constant repainting is required mainly to offset mechanical abrasion. Two coats must be used and scale must be completely removed before applying prime coat.

3. **Iron and steel surfaces exposed to slightly gaseous conditions**
 High grade machinery enamels using the best types of synthetic resins are satisfactory when care is exercised in application of the coatings. The success depends entirely upon the prime coat. With clean surfaces free from moisture, oil and scale, and a prime coat applied not too thin, followed by a second coat of the same paint after complete drying of the prime coat, the results have proved to stand up very well. Care must be given to the drying of the prime coat. If possible, doors and windows should be opened, or other methods employed to increase the supply of fresh air when coats are drying. It will be found that under a slightly gaseous atmosphere that the paints will take considerable time to dry and will not last their expected life.

4. **Aluminum Paints, exposed to concentrated gaseous conditions, high humidity and without sunlight**

 Samples were tried with a large number of aluminum paints using various types of vehicles and also coatings over bituminous paints, and in every case the results were unsatisfactory. The aluminum color continually darkened with a final color of a very dark grey.

5. **Preparing iron and steel surfaces**

 The most effective method of removing mill scale is by sand blasting and shot blasting.

Assistance in compiling information for this article was courteously given by Mr. C. L. Cook, City Chemist.

DISCUSSION

Mr. Johnson: What vehicle do you use, Mr. Van Norman?

Mr. Van Norman: Wood oil.

Mr. Goudey: In the presence of hydrogen sulphide gas, is there a yellow discoloration of zinc base paints?

Mr. Van Norman: There may be a slight discoloration but it is not marked. Non-bilge paints do retain their colors. I didn't mean to infer just white.

Mr. Parkes: Our experience at Terminal Island though more brief than those of Mr. Van Norman agrees to a certain extent. Hot applications of coal tar are best but they are mean to apply because of burns and difficulty in getting a smooth job. Heavy coal tar base paints are available. We have used one manufactured by Wailes-Dove-Hermiston which goes on cold and builds up with two or three coats to a thickness of possibly 2/32 in. and is perhaps as impervious as a hot coating. While a good substitute, the hot coating is probably better. We are experimenting with a new product called cold marine glue, samples of which have been supplied to us. The marine glue goes on hot and remains flexible and sticky in contract with bitumastic enamels which are brittle and crack with the slightest movement. It is claimed the marine glue can be applied with a gun. We hope to tell more of these experiments some other time.

Mr. Kimball: Mr. Van Norman, have you used aluminum paints?

Mr. Van Norman: Yes. Aluminum paint, however, is merely finely ground aluminum added to some vehicle. We have used several grades manufactured by the General Paint Co. One called industrial aluminum paint with synthetic rouge as a base or vehicle has a hard surface, does not bleed through with heat or exposure and is very satisfactory. I am told, though I have never used it for the purpose, that a coating of aluminum paint will kill the bleeding through of bitumastic foundations and permit application of decorative coatings.

Mr. Kimball: Can coal tar paint be applied to metal surfaces under water?

Mr. Van Norman: Yes. When applied to spiders on the inside of Dorr screens, under water, the same protection is obtained provided the

coating isn't fractured. Under water paint does not have to hold up under gas conditions. Concrete under water at our plant is as good as the day it was poured.

Mr. Young: We have experimented with titanium oxide paint and there is a possibility that it will serve where zinc and lead oxide paints discolor. I would like to say to Mr. Parkes that marine glue is good so long as gasoline and oil don't get on it.

Mr. Van Norman: We have some marine glue in service but I am not prepared to report on it now. There is one more point I might mention about coal tar paint,—with gasoline or other thinners it will curdle. I do not recall the name of the special thinner, but it is something like coal-oil.

Mr. Allen: Mr. Young mentioned titanium oxide base paints with which we have had good results for several years. These paints do not discolor in the presence of hydrogen sulphide.

Mr. Van Norman: In answering the question, "Have you used any fish oil paints?" replied, I gave up fish oil a long time ago because I couldn't let go of it.

Mr. Young: Though I haven't had any experience with its use, there is a fish oil paint that will dry.

Mr. Allen: Rustoleum is a fish oil paint.

Mr. Van Norman: Now that you mention it, Rustoleum does look good, but I don't want to report on it yet. I painted a ¾-in. rod without bothering to scrape off the rust. After three weeks' exposure to the weather, I scraped it, and it looks good. It does arrest the progress of rust.

Mr. Woodward: On your visit to our plant you will observe interior painting with Rustoleum with good results. There is a non-corrosive aluminum paint called Permite that does not powder or peel.

Mr. Hoskinson: Our experience has been that aluminum may be put on over asphalt or coal tar base paints and that shellac is a good protection for aluminum paint. Light colors may be applied over aluminum for decorative purposes, but we have not had good success in the presence of hydrogen sulphide. We have also employed priming coats of red lead with a synthetic vehicle called "Gym" finish. Synthetic bakelite varnish when used as a vehicle for red lead appears to provide a good protective base coat but before recommending it we must obtain further results.

Mr. Farnsworth: Mr. Tennent, you spoke of the use of primers. I do not understand the use of a primer.

Mr. Tennant: A primer is the first coat of paint applied. In woodwork it is supposed to penetrate the pores of the wood and provide a base for additional coats of paint. The primer should be very thin. In metal work the primer may be either the first or the second coat applied. On structural steel a coat of linseed oil may be applied followed by one or more coats of red lead. The primer is the real protective coating and the additional coats are for ornamentation or further protection.

The closing time for this session prevented further discussion on this subject.

ELECTROLYTIC CORROSION

By RICHARD POMEROY*

An attempt to present the subject of electrolytic corrosion necessarily involves the use of certain knowledge regarding corrosion in general. Therefore attention is directed, in the first part of this paper, to certain of the fundamental facts of corrosion. Emphasis is given to those phases of the subject which have a bearing on the electrolytic phenomena, and which may be related to the problems encountered by the sanitary engineer and sewage plant operator.

General Principles

The corrosion of a metal is a process whereby the metal is oxidized. The term "oxidize" in this connection is used in its general sense, meaning any change whereby the metal takes on a positive valence, or is converted from the metallic state to a compound. Whenever a metal is oxidized, or corroded, some other substance must be reduced. The substance which is reduced is the oxidizing agent of that reaction.

The most common of all oxidizing agents is oxygen. If oxygen combines directly with iron, the iron takes on a positive valence. At the same time the oxygen takes on a negative valence or charge, and therefore is reduced.

Oxygen may oxidize metals not only when it is in the form of a gas, but also in solution. Under ordinary conditions iron is not corroded appreciably by water devoid of oxygen, but it may be corroded by aerated water. The removal of oxygen from boiler feed water is an important method of corrosion control, especially where high pressures and temperatures are involved. Sewage devoid of oxygen is practically noncorrosive, but where there is turbulence or aeration it may become corrosive. Not only oxygen, but also other elements, such as sulphur and chlorine, may oxidize metals by direct combination.

When other oxidizing agents are not present, metals may be corroded by hydrogen ions. A familiar example is the action of strong acids on iron or other metals. The hydrogen ions lose their positive charges and so are reduced to hydrogen gas, while the metal is oxidized and dissolved to form a salt. Some metals are so easily oxidized that they do not require the high hydrogen ion concentration of strong acids; they may be oxidized by the hydrogen ions of water or even of alkaline solutions. The action of water on sodium is a familiar example.

Under certain conditions water may react directly with other metals such as aluminum and zinc and even with iron. When iron is being dissolved in chlorine solution to produce ferrous or ferric chloride, as in the Scott-Darcey process, the surface of the iron becomes so active that it reacts not only with chlorine but also with the water, producing hydrogen gas. The oxidation of iron by oxygen generally stimulates the simultaneous oxidation by water with hydrogen evolution.

*Research Chemist, Los Angeles County Sanitation Districts.

When metals react with hydrogen ions in acids or in water, it often happens that the film of hydrogen gas which forms on the sufrace of the metal acts to retard greatly any further reaction. If oxygen is present in the solution, it may react with the hydrogen under these conditions, forming water, and by removing the hydrogen film in this way it may permit the action to proceed. Because of this, oxygen generally increases the rates at which acids attack metals.

The corrosion of iron by aerated water is often explained by assuming this intermediate formation of a film of hydrogen. In some cases there is room for doubt as to whether this explanation represents what actually happens, or whether the reaction may not proceed some other mechanism. Practically it makes little difference how we imagine the reaction to proceed. It is sufficient to note that, in general, when an acid corrodes a metal slowly with evolution of hydrogen, the rate of corrosion will be greatly increased if oxygen is supplied.

Of particular interest in the industry of sewage disposal is the behavior of metals in the presence of soluble sulfides. Most metals have a greater tendency to form sulfides than they do to form oxides. Aluminum is an exception to this rule. The oxide or hydroxide of any common metal other than aluminum, if placed in a sulfide solution, will be converted to the sulfide of that metal. It follows that if a metal corrodes in the presence of a sulfide solution, the corrosion product will be essentially a sulfide of that metal, except in the case of aluminum. It also follows that sulfides will in general tend to accelerate corrosion, although other factors may obscure this tendency.

The sulfide ion by itself cannot act as an oxidizing agent. Therefore some other substance must be reduced when sulfide corrosion occurs. usually it is either hydrogen ions or oxygen which acts as the oxidizing agent. Oxygen of course is the more effective, with the result that corrosion by waters containing both sulfides and oxygen is likely to be severe. Fortunately the tendency of sulfides and oxygen to react with each other prevents these cases from being more common.

Iron, if immrsed in a pure hydrogen sulfide solution, will be attacked with evolution of hydrogen. This attack will occur even in sulfide solutions having a pH as high as 6.5, but it is negligible if the pH is above 7.5*. The simultantous presence of oxygen increases the attack. A centrifugal pump of the Los Angeles County Sanitation Districts, handling tunnel water containing both sulfides and oxygen with a pH of about 7.4, was so badly corroded that the impeller fell to pieces in less than a year.

The behavior of zinc is similar to iron, but the action is more rapid. Copper has a strong tendency to form the sulfide, but is too low in the electromotive series to be oxidized by hydrogen ions under ordinary conditions, and for this reason it will not react appreciably with hydro-

*Experiments at the laboratory of the Los Angeles County Sanitation Districts showed a corrosion rate of 108 mg. per sq. dm. per day for iron in distilled water saturated with hydrogen sulfide (5-day exposure). Hydrogen evolution was apparent. In another solution saturated with hydrogen sulfide, but with enough Na2S added to hold the pH at 6.2, the rate was 72 mg. per sq. dm. per day. In a third test enough Na2S was added to hold the pH to 7.4 and the observed rate was 6 mg.per sq. dm. per day. Addition of 3% NaCl to the last solution had little effect.

gen sulfide solutions unless oxygen is also present. But even the simultaneous presence of oxygen and sulfides does not lead to a severe attack of copper, probably because the sulfide film is quite protective.

Of practical importance at the sewage plant is the behavior of metals in digesting sludge. Sludge contains from a fraction of a part to several parts per million of sulfides in solution. In experiments at this laboratory, several kinds of metals were immersed for 30 days in bottles of raw unseeded sludge, raw sludge seeded with 25% of digested sludge, and in seeded and unseeded sludge to which were added 3,000 ppm of Na_2SO_4. In the latter two mixtures the dissolved sulfides rose to concentrations as high as 160 ppm, in contrast to 7ppm and 3 ppm as maxima for the unseeded and seeded sludges without the added sulfate.

Stainless steel and aluminum were practically unaffected in these sludge mixtures. Bronze, Monel, and Everdur copper were discolored, with slight attack of the metals. The worst attack in this group of three metals was suffered by the Everdur copper in the seeded sludge with added sulfate, but even in this case the rate was only 2.4 mg. per sq. dm. per day, or an average penetration of 0.0004 in. per year.

Iron samples were immersed in seeded and unseeded sludge with 750 ppm of Na_2SO_4, in unseeded sludge with 5,000 ppm of NaCl, and in unseeded sludge with 3,000 ppm of Na_2SO_4 plus 5,000 ppm of NaCl, in addition to the four mixtures used for the other metals. Corrosion rates did not differ greatly among the various mixtures, but were somewhat higher in the seeded samples; were higher with 750 ppm of Na_2SO_4 than with none or with 3,000 ppm, and were lowest in the samples containing NaCl. It appears that the sulfides had an accelerating effect, but that the principal factor was the vigor of gas production—those mixtures which produced little gas, and hence which had little agitation, caused little corrosion. The rates varied from 3 to 12 mg. per sq. dm. per day. The highest rate corresponds to an average penetration of 0.0022 in. per year, and hence is unimporant except possibly in the case of pipes of thin metal.

Zinc was the only metal which suffered serious attack in the sludge mixtures. The rates of corrosion varied from 160 mg. per sq. dm. per day in seeded sludge to 340 mg. per sq. dm. per day in unseeded sludge with added sulfate. The higher rate corresponds to an average penetration of 0.068 in. per year. This rate is high enough to remove a relatively thick galvanizing in 10 days.

These experiments were of very limited scope, and do not represent a thorough investigation of the subject, but they apparently indicate that zinc is of no value in digestion tanks, that iron is satisfactory for nearly all uses, and that stainless steel, aluminum, copper, and the copper alloys would show very long life in digesting sludge. Similar behavior would be expected in septic sewage. The observations on iron are in accord with the verdict of practical experience. Occasional instances of serious corrosion of iron in sludge doubtless can be explained by electrolysis, as will be pointed out.

All metals which are commonly used in construction have a ten-

dency to be oxidized when exposed to air or to water containing oxygen, and some tend to react with water devoid of oxygen. The tendency to react, however, does not tell us much about how fast the corrosion will proceed. The tendency to react, which may be measured by the free energy decrease, or by an electrode potential, is one thing, but the rate of reaction is quite another thing. The rate of a corrosion reaction at ordinary temperatures is determined principally by the conditions at the surface of the metal. The most important technique in minimizing corrosion is to establish and preserve on the surface of the metal a film or coating which will prevent the oxidizing agent from reaching the metal.

Most metals protect themselves to a greater or lesser degree by the products of corrosion. Thus aluminum, which has a strong tendency to combine with oxygen, will maintain a bright, untarnished surface for an indefinite length of time when exposed to a dry atmosphere. This is explained by the formation of a film of oxide on the surface of the aluminum, so thin that it is transparent, but so perfect that it prevents any further reaction. As long as this film is intact, the metal is safe, but if a piece of aluminum be placed in a slightly acid solution the oxide becomes soluble enough to allow the aluminum to react. Likewise, if it be placed in an alkaline solution in which the oxide is also soluble, corrosion takes place with evolution of hydrogen.

Various other metals form oxide films of varying properties. With lead, zinc, and copper the films are quite thin and they provide good protection, at least in neutral solutions, but they are not thin enough to be transparent as in the case of aluminum. With iron, the oxide gives only mediocre protection, and thick layers of rust will form in certain types of exposure. At pH values below 5, the oxide becomes appreciably soluble, and the metal corrodes with evolution of hydrogen. In the medium range of pH values between 5 and 10, the hydrogen ion concentration has little direct effect on the properties of the film. At pH values above 10 the properties of the film are greatly improved, with the result that iron shows good resistance to corrosion in strongly alkaline solutions.*

The champion of all common metals in the matter of oxide film formation is chromium. Not only is the film so thin as to be transparent, but it is highly resistant to attack. It dissolves only slowly in either strong acids or alkalis. In the case of strong acids, if oxygen or an oxygen-supplying substance is present, the film will restore itself as fast as it is dissolved, with the result that the corrosion of the metal will be very slow, but in strong acids such as sulfuric, if devoid of oxygen, the slow breakdown of the oxide film will be followed by fairly rapid corrosion of the metal. Thus in this case oxygen plays a role opposite to that which it usually plays in acid corrosion. Chromium is a rather expensive metal, but fortunately it can be alloyed with iron to give alloys of excellent mechanical properties, and in amounts as low as 10 to 30% it imparts good resistance to corrosion. This is the secret

*Wilson, R. E. "The Mechanism of Corrosion of Iron and Steel in Natural Waters, and the Calculation of Specific Rates of Corrosion" Ind. Eng. Chem. 15 (1923), 127-33.

of stainless steel, which, if genuine, is a steel alloy with 18% chromium and 8% nickel.

Principles of Electrolytic Corrosion

With this background of information about corrosion in general, we may consider electrolytic corrosion. It will be recalled that corrosion is a reaction in which the metal acts as a reducing agent, and some other substance acts as an oxidizing agent. In electrolysis it is not necessary for the reactants to come into contact; the metal may be oxidized at one point and the oxidizing agent may be reduced somewhere else. The positive charges which the oxidizing agent gives up at one point are transferred along the conductor to the metal which takes them in being oxidized. (More accurately speaking, negative electrons are transferred from the metal to the oxidizing agent.) In order for electrolytic corrosion to take place, a metallic path must be provided between the place where the reduction is taking place (the cathode) and the place where the metal is being oxidized (the anode) and a conducting solution must bridge the two points in order to complete the circuit.

Practically any reaction of corrosion can be made to take place electrolytically, and all corrosion of metals in contact with aqueous liquids probably does proceed more or less by electrolysis.

The phenomena of electrolytic corrosion will be described in three divisions: 1—corrosion by currents arising spontaneously from differences in the solution in contact with a single metal; 2—corrosion by currents arising from differences in metals; 3—corrosion by stray currents.

Electrolysis Involving One Metal

The electrolytic corrosion of one metal in contact with two solutions of different composition is a phenomenon of such widespread occurence that it is not ordinarily thought of as electrolysis. Whenever a metal is immersed in a liquid which can corrode it, there is a tendency for differences to develop in the composition of the liquid at the metal surface. At places where the metal surface is more active, the concentration of the oxidizing agent will be depleted faster than at other places which are less active, and thus a difference will be created in the concentration of the oxidizing agent. Or, suppose that the rate of corrosion is uniform, but that the oxidizing agent has less ready access to certain parts of the surface because of the shape of the piece of metal, or because of particles of foreign matter sheltering portions of the surface. In either case, when the oxidizing agent becomes depleted at one point on the metal while it is still present at another part, corrosion by lectrolysis will result. If the action is such as to perpetuate the difference, corrosion will be localized, thus causing pitting of the surface.

Consider the corrosion of iron in aerated water. When a clean piece of iron is immersed in water, it will begin at once to form an oxide film. This film hinders contact between the dissolved oxygen and the iron,

but it is able to conduct an electric current. Consequently it is possible for oxygen to give up positive charges to the metal through the oxide film, the oxygen thus being reduced, in the presence of water, to hydroxide ions. A place where this occurs is a cathode. (It is often assumed that the process at the cathode surfaces consists in the production of a film of hydrogen from the water, leaving hydroxide ions, and that oxygen then combines with the hydrogen to regenerate the water. The actual mechanism is immaterial; the net result is that oxygen is reduced, hydroxide ions are formed and the metal gains positive charges.)

The positive charges furnished by the oxygen of a cathode area can travel through the metal as an electric current. If they find a place where the solution is defficient in oxygen, or where the oxide film is weak or absent, then the iron at such a point may take them and go into solution as ferrous ions. At a short distance from the metal the ferrous ions will hydrolyse to ferrous hydroxide, and in so doing will cause the solution to become slightly acidic, according to the equation

$$Fe^{++} + 2H_2O \Longrightarrow Fe(OH)_2 + 2H^+$$

Where the concentration of hydrogen ions becomes sufficient the hydrolysis is prevented, and therefore there will be, next to the metal, a thin layer of a slightly acid solution of ferrous salts. Only when the ferrous ions are carried some distance from the surface by diffusion and by the electric current will they come into contact with water of high enough pH to permit the precipitation of the hydroxide. Thus it is impossible for the hydroxide to preciptate as a protective film on the surface of the iron. Consequently the iron surface at this point will remain clean and active.

The shell of ferrous hydroxide which builds up over the anodic area reacts on its outer surface with oxygen being converted to ferric hydroxide. Because of the efficiency of the ferrous hydroxide in absorbing oxygen, there is no chance for oxygen to reach the surface of the iron and inactivate it. The readiness with which the iron at these points can use positive charges tends to keep the piece of metal from becoming positive by the action of oxygen at other points, and so it diminishes the tendency of the rest of the metal to corrode. In other words, an efficient anodic area tends to keep the surrounding area cathodic and so protect it against corrosion. Thus the conditions which cause the electrolytic action tend to continue and to become more severe. The rapid corrosion of the anodic area causes a pit to develop in the metal at that point.

The determining factor in the rate of corrosion of this sort usually is the efficiency of the cathodic areas in their function of reducing oxygen. Oxygen deficiencies may occur on the cathode areas, and thus new anodes, or new pits, may arise. These new pits will then take their share of the positive charges which are made available by the remaining cathode, and so the rate of corrosion of each pit will be reduced. The cathode areas may slowly accumulate a thicker and thicker

film of rust, which hinders access of oxygen. Furthermore, lime, or a mixture of lime and rust, may precipitate on the cathode areas.

A cathodic area is an especially favorable place for the precipitation of lime from water which is slightly supersaturated with lime, and precipitation may occur even with water which is somewhat below saturation with lime. This results from the fact that when oxygen is reduced on the cathode, hydroxide ions are formed, and an increase in hydroxide ion concentration reduces the solubility of lime, thus forming precipitation. It is for this reason that corrosion in water supply systems can be controlled by regulating the composition of the water with respect to lime saturation. The principal influence of the hydrogen ion concentration on the corrosion of iron by natural water in the pH range between 5 and 10 is due to its effect on the solubility of lime*.

Without going into intricate theoretical details, the foregoing explanation substantially represents the process by which iron is pitted when in contact with water, and essentialy the same explanation applies to other metals as well. The pitting of a metal is prima facie evidence of electrolytic corrosion. The common occurrence of electrolytic corrosion will be evident to anyone who has noted the universal appearance of pits on corroded metal.

An important factor influencing the intensity of electrolysis of this and other types is the electrical conductivity of the water. Water with a high concentration of soluble salts will have high electrical conductivity. Other things being equal, a water of this kind will be more corrosive than one of low conductivity, for the obvious reason that electrolysis takes place more readily where there is less resistance to the flow of the current. The electrical resistance of soils is a good indication of their corrosiveness.

The difference of electrode potential which arises spontaneously because of local differences in the composition of the solution in contact with a piece of metal may be effective over greater distances when conditions are favorable. This is common when iron structures are buried in the ground. If a part of the metal is in soil containing oxygen, while another part is in soil devoid of oxygen, then electrolytic action will occur. Pipe lines are often laid in soils which are loose and aerated in some places, but which in other places contain much water, organic matter, and possibly sulfides. Such pipe lines (if electrically continuous) will carry currents from the aerated sections to the places where the soil is wet and organic-laden, with corrosion occuring in the latter places.

Similar action may arise beween structures in aerated soil or water and structures in septic sewage or sludge. A striking example of this was observed at a sewage treatment plant built on low sandy ground near the sea. The sand contains little organic matter, and allows access of oxygen to pipes and conduits buried in it at moderate depths. Somewhat deeper is a table of salt water. The sewage contains nearly 3,000 ppm of chloride. The pipes laid in the soil provide cathodes for the

*Langlier, W. F. "The Analytical Control of Anti-Corrosion Water Treatment" Jr. Am. Water Works Assoc. 28 (1938), 1500-21.

reduction of oxygen. Metallic contact is continuous from these pipes to structures in the digestion tanks and in the clarifier, and these structures become anodes. Thus the current flows to structures immersed in the sewage and in the sludge, goes from these structures to the liquid, thereby causing corrosion, passes through the concrete bottoms of the tanks, and returns through the salt water to the cathodic pipes. The high salt content of the ground water and of the sewage facilitates the flow of current, and causes a worse condition than would otherwise result.

Corrosion in the digestion tank has been especially severe, and is well illustrated on a row of manhole steps down the inside. Some of these steps, which were found by electrical tests to be not in contact with the reinforcing in the concrete, were not corroded, since they could not carry current to the sludge liquor. Other steps which were in electrical contact with the reinforcing, which in turn provided an electrical path from the piping, were reduced in places from a diameter of ¾ in. down to ¼ in. in 15 months. Thus the conclusion previously expressed, that iron can safely be used in sludge digestion tanks, needs to be qualified by the understanding that precautions must be taken to prevent electrolysis of this sort. It is to be expected that when the grounds of this plant are heavily fertilized and planted to lawns, the conditions will be much less serious, since the access of oxygen to the pipes will be largely cut off. In the meantime the electrolysis will probably be prevented by forcing the current to flow from the sludge to the metal structures by a method to be described subsequently.

Electrolytic corrosion of the type described thus far is sometimes referred to as "concentration cell electrolysis," but the term is somewhat confusing. The term "differential aeration" is also used, and comes much nearer to describing the phenomenon, although it is really not a difference in aeration but rather the complete absence of oxygen at one point, contrasted to the presence of oxygen at another, which causes the action.

When electrolytic corrosion arises from spontaneous differences in the oxygen concentration of water in contact with a metal, leading to pitting in the manner first described, the currents generally flows over paths less than an inch in length, and the pits are small and fairly close together. When the currents flow over greater distances, due to aeration differences maintained by external circumstances, the pits are likely to be larger and farther apart.

Electrolysis Involving Two Metals

The second source of spontaneous electrolytic currents is the coupling of two metals in the same solution. This phenomenon is called galvanic action. Suppose that a piece of copper and a piece of iron are connected in aerated water. Copper is scarcely corroded at all in water, but it can provide a good surface on which oxygen can be reduced. The positive charges which it gathers from the oxygen can be used readily by the pits which will quickly develop on the iron. In other words, the

copper becomes a cathode and helps to corrode the iron. The iron, because of its efficiency in removing the positive charges from the copper, tends to further diminish the corrosion of the copper.

When any two metals of different corrosion rates are coupled, the corrosion of the more corrodable metal will be increased, while the less vulnerable metal will generally be corroded less than if it were alone. Two uncorrodable metals, if coupled, will remain uncorroded.

The magnitude of the effect depends, among other things, upon the relative areas of the two metals. If a small piece of copper is connected to a large piece of iron, then the iron will not be seriously affected. On the other hand, if the area of the copper is large and that of the iron is small, then the corrosion of the iron will be severe. Thus, the use of steel rivets or bolts or trimmings on structures of copper, stainless steel, or other resistant metals will likely result in early failure.

An interesting example of two-metal galvanic action has been reported by Mr. Carl Hoskinson of Sacramento.* Centrifugal pumps used for water and for sewage were constructed with cast-iron impellers lined with bronze rings. When used on water, the iron adjacent to the bronze corroded so badly that the rings came off. However, when similar pumps were used with sewage the iron was not harmed, but the rings were corroded, indicating that the bronze was more susceptible to corrosion than was the iron when exposed under those conditions. (These observations should not be used uncritically as a basis for judgment in the design of pumps, for many factors must be considered.)

An outstanding example of galvanic corrosion occurred with the yacht "Sea Gull," built in 1915 at a cost of a half million dollars. The hull of this yacht was made of Monel metal with the exception of the stem, keel, stern-post and rudder frame, which were of steel. Both Monel and iron rivets were used. The vessel had been service for less than three months when failure of the iron rivets forced it into drydock. Examination of the rest of the hull at this time showed that corrosion of the steel parts was so severe that it was necessary to scrap the entire vessel.

Local differences in the composition of impure metals may give rise to local galvanic action. Before the science of corrosion was well developed, it was commonly assumed that the pitting of metals was due to variations in the composition of the metal. It is now generally recognized that pitting is due principally to differences in the liquid at the surface of the metal. Nevertheless pits sometimes owe their origin to differences in the metal, especially in the case of aluminum, even though their subsequent growth may be due largely to the principle of "differential aeration."

This phenomenon of electrolysis from the coupling of two metals may sometimes be put to good use. The outstanding example of this is the galvanizing of iron, in which the iron is given a coating of zinc. The zinc corrodes more readily than the iron, and thus an exposed spot of iron is rendered cathodic and so is protected. If a pit develops

*Private Communication.

on the zinc, it penetrates until it reaches the iron, and then it must stop. As long as a considerable part of the surface is covered with zinc, corrosion of the iron will be slight.

Galvanic corrosion from two-metal combinations can generally be recognized by its distribution. It is most severe near the junction of the two metals, and is seldom observed over distances of more than a few inches.

Electrolysis from Stray Currents

The third division of electrolytic corrosion phenomena deals with the results of stray electric currents. Direct currents are the chief source of concern in this connection. They come for the most part from direct-current electrical installations, and especially from street railways. In the electric railway system the circuit from the power house to the train makes use of a trolley wire, or third rail, on one side, and the railway tracks on the other side. Hence when trains are operating, a current is flowing through the tracks. However, it does not stay in the tracks, but distributes itself along all possible paths in proportion to their respective conductances. If a pipe line parallels the tracks, current will leave the tracks in one section and go to the pipe line, and then at some other place the current will leave the pipe line and return to the tracks or to some other structure. In a city the currents may follow devious paths. They will vary at different times of the day, and with the passing of trains; polarities will reverse in some sections.

The flow of current on to the pipe, and through the pipe, does no harm, but when it leaves the pipe it takes metal with it. A current of one ampere flowing for one year under ideal conditions will oxide about 20 lb. of iron, and amounts of other metals in proportion to their equivalent weights. The amount removed from pipe lines under ordinary conditions is less than the theoretical maximums; it may vary from 2 to 10 lb. per amp. per year. Unfortunately the corrosion of iron by a current in this way proceeds by pitting just as in the case of local action, and thus a pipe line will often fail when 10% or less of the iron has been corroded.

Corrosion from stray current cannot always be identified on the basis of purely superficial observations, for the results are not characteristically different from the results of other types of corrosion. In the vicinity of electric railways, or any electrical equipment which may ground direct currents, corrosion by stray currents is to be expected. Corrosion that occurs under conditions where it would not otherwise be expected may lead to the suspicion of stray currents. The positive identification of this type of corrosion depends upon establishing the presence of currents, or of differences of potential between various metallic structures or different parts of the same structure. In the case of a pipe line, a difference of potential between two points indicates a flow of current, and the amount of current flowing can be calculated if the resistance of the pipe is known. A current entering or leaving the

pipe can be detected and measured by measuring the potential differences in the soil close to the pipe.

Alternating current as well as direct current may cause corrosion, but the amount of corrosion of iron by an alternating current is only 1% to 5% as great as by the same amount of direct current. The corrosion of copper by alternating currents is practically nil.

Stray-current electrolysis of pipe lines is not necessarily limited to the outside of the pipe. If a current is flowing through a water pipe, some current will also flow through the water, for the current will distribute itself along all possible paths according to their conductances. The current which goes into the water will be far too small to affect the pipe seriously, but it may put enough iron into the water to affect the quality of the water for domestic uses. Mr. A. R. Todd of the Water Works of Wheeling, West Virginia, reports appreciable amounts of iron going into water from the inside of pipes by virtue of alternating current flowing through the pipes.*

Remedial Measures

Of practical importance to the engineer and operator are the questions of what to do about these types of corrosion. The different cases may be taken in order.

Prevention of electrolytic corrosion from "differential aeration," where the action is due to local differences in the solution at the surface of the metal, is simply the general problem of preventing the corrosion of a metal in other than atmospheric exposures. Mention has already been made of the removal of oxygen from water to make it less corrosive. This may be done by boiling, by heat in connection with vacuum, by adding sodium sulfite, or by passing the water over scrap iron of large surface area.

Aside from these de-oxygenating processes, the chief methods of preventing corrosion depend upon providing a protective surface coating. The coating may be a corrosion-resisting meal, such as tin, nickel, or chronium, or it may be zinc, which protects the iron largely by galvanic action. Coatings other than zinc are not widely used for ordinary construction, and even zinc coatings are not of great value in soil or under-water exposure. They are not indicated for use in sewage or sludge. Protective films may be formed electrochemically, as in the Parkerizing of iron or the anodic oxidation of aluminum. Protection may be accomplished by causing the water in contact with the metal to form a film, as by adding sodium chromate, sodium phosphate, or sodium silicate to the water, or by keeping it nearly saturated with lime. Or the protection may be provided by paint, tar, or other similar material. Structural steel and iron are usually protected from atmospheric exposure by paint, but for soil or under-water exposure a coating is required which will provide good electrical insulation, to stop the electrolytic currents, and which will be relatively permanent. Coal-tar enamels have proven best for this purpose.

*Todd, A. R. "Some Operating Kinks" Water Works and Sewage. 84 (1937) 477-9.

In cases of exposures where corrosion will be severe in spite of these measures, solution of the problem may be found by using metal thick enough to outlast the forces of corrosion, or by using a metal of more suitable properties. In this connection it may be well to warn the engineer that little can be gained by changing from one brand of iron to another. All forms of iron and steel are similar in respect to corrodability.* No alloying element in small amount has any important effect on the corrosion resistance of iron and steel, except for a beneficial effect of small amounts of copper for certain exposures. There are no secret alloys, and in most cases the corrodability of an alloy is roughly the average of the corrodability of its constitutents.

In the case of electrolysis such as that which arises spontaneously in pipe lines, and between metals in aerated water or soil and in sewage or sludge, which differs from the local action first considered only in the distance which separates anode and cathode, use is often made of insulating couplings to stop the flow of current. There may be installed at regular intervals, or, better, in such locations as to separate the anodic and cathodic sections of the pipe or structure. Protective coatings are also used to control this type of electrolysis. When using protective coatings, however, an important fact must be borne in mind: such coatings are of value only on the cathode regions. They prevent oxygen from reaching the cathodic surfaces, and they obstruct the flow of current on to the metal at those places. On the anodic surfaces the coating may greatly diminish the flow of current, but no practical coating is a perfect insulator, and some current will flow. The effect of the coating will be to concentrate the current at a few points, and those points will suffer severe corrosion, leading to earlier failure than if the current had been distributed over a larger area. Thus we have the apparent paradox that a pipe line should be protected by applying a coating on the sections which do not tend to corrode, while leaving bare those sections where corrosion occurs. In the case of the sewage plant which was described previously, an attempt to protect the structures in the digestion tank by coating with tar would be not only futile but positively harmful. **Metals in unaerated sewage or in sludge should always be left bare.** If the situation does not permit electrolysis to occur they do not need coatings; if electrolysis can occur they should not have coatings.

In the case of aerated sewage, it is necessary to consider more factors than can be outlined in detail in this paper, but protection usually is not required.

The answers to two-metal galvanic corrosion problems are usually found in the proper choice of metals. Generally expert advice should be sought on this point when valves, pumps, etc. are being designed with more than one metal. However, this general rule can be remembered: never use small surfaces of a metal susceptible of corrosion, under the conditions of use, in conjunction with large surfaces of a less susceptible metal.

*Logan, K. H. Jr. Research. Nat'l Bureau of Standards, 16 (1936) 431-66.

Electrolysis of pipe lines by stray currents can be minimized or prevented in various ways. The first step is to map the currents, using methods which have been developed by those familiar with this field. In sections where the earth is positive, the pipe should be insulated as well as possible to keep the current from getting on to it. Regions where the earth is more negative than the pipe should be left bare, unless other protective methods introduce factors which dictate otherwise. Insulating couplings, if wisely installed, are useful. It is often possible to drain currents from the pipe to rails or other structures which are negative.

Recent years have seen the advent of a new method of corrosion control, effective not only against stray currents, but against all other forms of corrosion as well. It is the method of cathodic protection, putting the forces of electrolysis to beneficial use. The principal is to make the entire pipe or other structure cathodic by giving it a negative potential. If a pipe is sufficiently negative to cause some current, even if a very small amount, to flow from the soil to the pipe, then corrosion is reduced to a small fraction of what it would be in the absence of such a current.

In order to maintain a negative potential on the pipe or structure, it is of course necessary to provide a complete electrical circuit. This is done by burying anodes at suitable places in the soil. In the case of pipe lines the anodes are usually placed at a distance of 200 feet or more from the pipe. These anodes will be corroded, but they may be made of scrap pipe or rails and can be replaced at little cost.

In this type of protection for pipe lines, it is customary to give the pipe a negative potential of 0.85 volt or more relative to a copper-copper sulfate electrode in contact with the soil*. In order to maintain this potential, it is necessary that the pipe be reasonably well insulated. Different coatings which may be applied to the pipe vary in their electrical properties, and much research is being done with the object of improving the quality of such coatings. Asphalt coatings, which are widely used, provide fair insulation, but coal-tar coatings are decidedly superior. The resistance of any coating decreases with time, probably due to absorption of water.

The electrical resistance of a coating after a year or two of service determines its suitability for use in connection with cathodic protection. A high-grade coal-tar coating may have a resistance as great as 50,000 ohms on a square foot of surface, but the resistance of a poor asphalt coating may become as low as 300 ohms per square foot. In the former case the current requirement for cathodic protection will be about 0.1 amp. per mi. of 12-in. pipe, and the total capital and operating cost will be about $6 per mi. per year. In the case of the low-resistance coating, 15 amp. per mi. will be required, and the cost will be $300 per mi. per year.

Various sources of current have been used to maintain cathodic protection. In one case, tracks of a street railway which were at a negative

*Ewing, S. Nat. Gas 16 (1935) No. 3,5-10; No. 4, 16-20.

potential were used. In Texas windmills have been used to run d. c. generators. Most commonly transformers and rectifiers are used to produce the direct current from ordinary alternating current. Recently some pipe lines in Louisiana have been protected by making anodes of zinc and letting the galvanic action keep the steel pipes negative, without the necessity of supplying current from an outside source. This procedure is identical in principle with the galvanizing of iron. In one case the zinc is remote from the steel pipe, being connected to it by wire; in the other case the zinc is put on to the pipe as a coating.

The oldest large-scale installation of cathodic protection has been in service since 1930. Many of the first installations were made on old lines which had begun to show leaks with increasing frequency. Generally leaks ceased to appear when cathodic protection was applied. The method has had such striking success that it is becoming very popular, and it may be counted on as an important weapon in the continuing fight against corrosion.

Summary

Corrosion of a metal is a reaction in which the metal is oxidized. Oxygen is the most common oxidizing agent; hydrogen ions are next in importance. Sulfides generally accelerate corrosion, but cannot themselves act as oxidizing agents. The combination of sulfides and oxygen is generally very corrosive. Septic sewage and sludge, being devoid of oxygen, have little effect on any common metals other than zinc.

Electrolytic corrosion is a process in which the metal is oxidized at one point while the oxidizing agent is reduced somewhere else. The commonest form is that due to differences in the composition of the liquid in contact with a metal; it leads to common pitting of corroded metals. Next in importance is the type due to combinations of different metals. Corrosion by stray currents is often serious, especially in iron or steel pipe lines.

Remedial measures include: 1—Removal of the oxygen from the water. 2—Coating of the metal. Coatings are effective only on cathodic areas; metal immersed in sludge or septic sewage should always be left bare. 3—Separating cathodic and anodic areas by insulating couplings. 4—Cathodic protection. This last method has come into use only recently, but it has been found to be highly effective in pipe-line protection.

DISCUSSION

Mr. Wilson: Mr. Pomeroy, I would like to mention a test we conducted in conjunction with the International Nickel Co. About twenty different alloys like Monel were supplied in 2 in. discs and strung on a spool. One set of discs were separated by bakelite insulators and the second set was separated by galvanized pipe so that the discs were grounded to each other. After six months exposure and when the International Nickel representatives were again present, the discs were weighed. The insulated discs had become wafers and the non-insulated ones were hardly affected which was opposite to the expected results.

We have been unable to account for the fact that the insulated discs of such material as Monel corroded.

Mr. Pomeroy: Were these pieces of metal immersed in sewage?

Mr. Wilson: No, in damp air in test manholes, where there was 100% saturation of moisture. Slime ran over the specimens at times.

Mr. Pomeroy: I couldn't undertake to explain your results without asking a great many questions, so perhaps it would be best for us to talk about it later, rather than from the floor.

METALLIZING-COATINGS OF NON-CORRODING METALS

By L. E. KUNKLER*

I appreciate the opportunity of appearing before you to present some of the interesting facts relative to Metallizing applications with the hope that an entirely new field of application will be discovered through your having this information on the process and your progressiveness in seeing the possibilities for practical application in your field.

We do not have a very large file of Metallizing applications in the sewage treatment plants though we do have a tremendous amount of information on use of Metallizing in other fields including that of water treatment which we consider to have a certain amount of parallelism to sewage treatment.

So that you can determine the possibilities and advantages of Metallizing, in your field, I want to present:

1—The equipment
2—Preparation of surfaces
3—Uses in industry, and
4—Application in water treatment field.

Equipment — Metallizing is accomplished by a small gun embodying a miniature power plant and foundry. The power plant is a turbine operated by compressed air. Its function is to operate the gears, propelling the wire through the foundry. The foundry is a nozzle very similar to that of a cutting torch. The wire comes through the center of the nozzle, with four jets surrounding the wire. Through these jets passes a mixture of oxygen and acetylene which provides a flame of 6,000° F. to melt the metal.

Any metal can be sprayed, from lead and steels to tantalum and tungsten, including gold and silver. These metals have different melting points but the nozzle has one flame temperature so to compensate for the different melting points of the metals there is a small turbine adjustment screw on the side of the gun. This regulates the speed of the turbine. For the lower melting point metals we speed the turbine

*President, Metallizing Company of America.

up and drive the metal wire through the flame at greater speed. For the higher melting point materials we must slow the turbine.

Lead can be propelled, melted, and atomized by the gun at 100 lb. per hour while the high carbon rate is 9 lb. per hour and tantalum 5 lb. per hour.

Preparation — Sprayed metal is bonded by being splashed, in a plastic state, into the keys of an extremely rough threaded or grit blasted surface. The former is produced by setting a specially ground tool below center. The grit used for blasting must be very sharp to tear the surface. Either method of preparation opens thousands of little keys in the surface, into which the plastic metal locks itself. However, constant pounding and shock will destroy this bond.

On flat surfaces steel grit blasting or sand blasting must be used as preparation to receive the sprayed coating. If you use sand, it must be a sharp sand so it will tear the surface and open up thousands of little keyways. On outside diameters of shafting or on internal surfaces the preparation is rough machining and one can very easily tell whether a surface is properly prepared when one knows there must be many little barbs or claws on the piece to hold the sprayed coating. However, in some cases such as that of the bearing surface on an axle to be metallized it is impractical to rough thread because of the cost of removing the axle to mount it on a lathe. Where one has to build up .003 to .008 in. on such a surface to receive a press fit, prepare the surface by grit blasting.

Uses in Industry. Metallizing has found a very important place in industry as a tool for salvage and the lowering of maintenance costs as well as for improving products.

In your industry I believe you would have pumps, shafts, impellers, armature shafts, etc., that could be built up by Metallizing. In some instances you might have a steel shaft that would be improved by a coating of bronze or stainless steel. In other cases bronze rods might have certain sections which could be built up by spraying stainless steel. Such shafts as have been in service and are worn could be restored to original dimensions by Metallizing.

Any metal can be sprayed.

We know from experience in other fields that surfaces built up with sprayed metal will have much less wear than new shafting.

I would like to call your attention to some reports on jobs in this machine element field that have been in service for a period of time, proving the advantage of metallizing.

The Cities Service Gas Co. compressor plant at Wichita, Kansas had two Cooper Bessmer compressor rods rebuilt by Metallizing with No. 1 stainless steel. These were put into service on March 8, 1935. The rods are in use on No. 7 and No. 8 engines, using McCarta packing. They are 4 in. in dia. and from a Cooper Bessmer natural gas compressor having a 13½-in. piston with 36-in. stroke, 1000 h.p. These rods have run 22,024 hours which is equal to 2½ years continuous run. They were

inspected March 17, 1938 and new packing installed but the important thing is that the actual wear on these rods after this length of service was .008-in.

Going from compressor rods to crank shafts, it is interesting to quote from a paper presented before the Society of Automotive Engineers meeting at Newark, N. J., Nov. 10th by Mr. W. J. Cumming of the Surface Transportation Co. of New York. They are using MOGUL Metallizing equipment for building up worn crank shaft journal bearings in their bus engines.

"Practically all the older street buses in New York City have had crank shaft bearings Metallized and many of these reconditioned engines have gone over 100,000 bus-miles which proves the wearing qualities of sprayed coatings."

As we consider the rebuilding of shafts, rods, pistons and journals one of the most important uses for the Metallizing process, we would like to call your attention to a series of tests made by Mr. Harry Shaw, consulting and research engineer of the College of Technology, Manchester, England.

In making these tests the Shaw Frictograph was used. This device was conceived and built by Mr. Shaw for the express purpose of getting accurate data concerning the friction set up by rotating members under various conditions of speed and pressure. In the Frictograph a shaft of 2-in. diameter rotates in a complete bearing of any desired metal and the bearing is so arranged that it can be made to exert any predetermined pressure upon the shaft. This is accomplished by a lever system which is actuated by a diaphragm type dynamometer, the load being recorded by pressure guage connected to the dynamometer. The friction between the rotating member and the bearing creates a torque which is transmitted to the bearing housing and further transferred through another lever system to a second oil dynamometer to which is connected another recording guage that measures the changes in friction. Knowing therefore the values of speed, pressure and torque it is quite easy to make rapid and accurate determinations as to frictional conditions which may exist between a rotating and fixed member.

Now the subject under investigation during these tests was the relative merits of sprayed metal surfaces as against hardened solid metal surfaces when being used as journals or under like conditions and it may be stated that the results were most gratifying as it showed that the sprayed metal surfaces possessed a decided superiority over the solid metal under any and all conditions. In those respects this was not unexpected as sprayed coatings have the property of absorbing oil which gives them an advantage under faulty oil flow conditions but on the other hand there has always been some question as to the actual worth of this advantage under operating conditions. Rather than make any further comments on the subject we will pass on the pertinent excerpts from the paper delivered by Mr. Shaw and let you judge for yourselves as to the value of sprayed coatings when used for bearing surfaces.

The tests were carried on at surface speeds of 445, 261 and 27 ft. per min. and the bearing pressures ranged from 200 to 2,000 lb. per sq. in. Preliminary to the tests the shafts were run in at 445 ft. per min. under a bearing pressure of 300 lb. as a means of conditioning them for the tests. The run lasted 10 hours and mineral oil was used as a lubricant.

Now these tests were quite elaborate and to go into detail would require more time than is available so we will confine our observations to the salient points.

1. The coefficient of friction of the sprayed steel coatings was from 5 to 30% less than that of the solid shafting under all conditions with but one slight exception: i.e., at a speed of 261 ft. per min. and at a pressure below 400 lb.

2. The solid shaft seized under a pressure of 1000 lb. when run at a surface speed of 445 ft. per min. Under the same speed conditions the sprayed shaft failed to seize up to a maximum pressure of 2000 lb. which was as much as could be applied by the machine. In a later test, using a different lubricating oil, the solid shaft seized at 750 lb. bearing pressure while it required over 2500 lb. pressure to cause the sprayed shaft to seize.

Another test was run by Mr. Shaw which was classed as an oil cut off test. In this test the speed of the shaft was 261 ft. per min. and the pressure applied was 300 lb. per sq. in. After the shafts were up to speed the lubrication was shut off and the shafts allowed to run dry. In slightly less than three hours the solid shaft seized but the sprayed shaft continued to run on to 22 hours before seizure took place.

Despite the increased load capacity and reduced friction of the sprayed metal in the laboratory tests it was thought that the sprayed metal might not stand up under conditions such as exist in an engine where loads are erratic and pulsating, so tests were carried out on crankshafts from twenty-two different engines, of which five were car engines, four commercial vehicle engines, five patrol bus engines, and eight diesel bus engines.

The crank shafts were reduced on half the journals to about 1/8-in. below size, built up by metal spraying with steel, and finished to size, this giving a sprayed thickness of about 1/16-in. One crankshaft from each class of engine was given a thickness of sprayed metal of only 1/32-in. Checks of the wear on the metal sprayed journals and on the ordinary journals were made over running periods of 1,000, 5,000 and 10,000 and 15,000 mi. and in no case did the wear on the sprayed journals exceed that on the ordinary journals. The difference in the thickness of metal spraying of from 1/32 to 1/16 in. appeared to have no influence on the wear.

The most remarkable effect of the metal sprayed journals was that the wear on the contacting bearings was much less than on those contacting with the plain journals. The wear was 40% less on an average and 55% less in the diesel engines.

I have devoted quite a lot of my time to giving you information on

the coating of shafting because I believe you have use for the Metallizing process for such salvage work. The building up of undersize parts is a very important use for Metallizing but there are many engineers who feel that Metallizing is of greater value in the corrosion resistance field.

Now in the corrosion resistance field, we, unfortunately, are limited to a very few metals for spraying on tanks and flat surfaces. This is due to the fact that it is necessary to polish the harder metals, such as 18/8 steel, when applied to tanks and on flat surfaces it is rather difficult to polish or grind stainless steel. The coating will blister and quite often one will grind through the .020-in. coating applied to a tank. So we only recommend that stainless steel, bronzes, and monel be used on shafting which is easy to machine or grind. From our experience in other fields we say to you, forget Metallizing with the harder metals on tanks, vats, etc.

Now for corrosion resistance we have zinc for our No. 1 metal. It is very economical to apply by the spray process. The cost of applying 3 oz. of zinc runs from 8c to 18c per sq. ft. Our No. 2 metal is aluminum, usually applied .016-in. in thickness, on which the cost runs from 60c to $1.00 per sq. ft. Lead is used in many cases and is applied 2 lb. to the sq. ft. We cannot apply a greater weight of lead as a greater weight would cause the bond to weaken and lift from the keyed surface. Cadmium is also used but today Cadium is too costly for most applications.

In your field for corrosion resistance you must use one of three metals and if zinc, aluminum or cadium is used by other methods, Metallizing can be adapted and will prove very practical and economical. Of course, one is able to apply these metals by our process to tanks whereas by other methods it is impossible where the tank is already fabricated. In some conditions sprayed lead is far better to use but one must consider that we can only apply 2 lb. to the sq. ft. and naturally, lead will be eaten away in some chemicals. Two pounds of lead will disappear more quickly than 12-lb. sheet lead but we have the advantage that every particle of sprayed lead is bonded to the base and if there is any damage to the coating one can patch the damaged spot.

Applications in Water Treatment—As I said at the beginning of this talk, there has been very few applications of sprayed metal in your field of which we have a record. However, many sewage dispoasl departments have used sprayed lead on exhaust blowers which has proven very practical and is recommended by us.

We have had a great deal of experience in the water treatment field. This is because of the wide use of zinc in the hot dip process.

DISCUSSION

Mr. Hoskinson: Does the operator require a mask for protection while spraying metals?

Mr. Kunkler: Yes. Operators must have protection when spraying lead, cadium and tin. The fumes from these metals are the only ones that are dangerous. The fumes from zinc are not dangerous. The protection consists of a mask providing fresh air to mouth and nose.

Mr. Allen: Is it true that impellers should be polished after they are metallized?

Mr. Kunkler: An impeller should be polished.

Mr. Allen: We had cast iron impellers which were corroding very badly. We put a metal spray on but it did very little good. Apparently the sprayed coating was porous and permitted liquid to get through and corrode the impellers.

Mr. Kunkler: Monel metal is porous to a certain extent when sprayed. All hard metals should be polished in order to give good service.

Mr. Rawn: Is sprayed lead as dense as poured lead?

Mr. Kunkler: Lead coatings as sprayed today are within a point of being as dense as lead sheet.

Mr. Rawn: Does the sprayed metal undergo any type of oxidation from high heats at which applied?

Mr. Kunkler: Oxidates are noticeable after spraying copper but with steel or lead there is very little visible oxide with the newer type of equipment. Copper is the only metal that has not been used successfully because of oxide inclusions.

Mr. Pomeroy: You spoke of lead coatings on the inside of manhole castings. Have you any data on how they stand up when exposed to gaseous compounds?

Mr. Kunkler: No I haven't any specific information except that in Los Angeles the Alhambra Foundry makes lead lined manhole covers. I do not know who they are for but since for a period of years new orders for coatings have come through they must be successful or else someone would stop spending the extra money to have them coated.

WARD'S ISLAND TREATMENT PLANT IN PICTURES

C. G. GILLESPIE*
and
C. C. KENNEDY†

Note: Mr. Kennedy presented the following description of the Ward Island Sewage Treatment Plant preceding the pictures which were explained by Mr. C. G. Gillespie. The Association is endebted to Mr. R. H. Gould, Director of Engineering, for the loan of the lantern slides.

The Ward's Island Treatment Plant, of which you have all read a good deal, was the first modern treatment plant to be designed in the City of New York. The design was started in 1929 and construction began two years thereafter. The plant was partially completed in 1933 when money ran out and construction work was stopped. Design and construction of the Coney Island Plant proceded, however, and it had the distinction of being the first modern treatment plant to be completed by New York City. Coney Island is the playground of greater New York, and this plant put in operation in 1935 made safe bathing and a ocean beach. When a P.W.A. allotment was made available in 1935, work was resumed on the Ward's Island plant which was completed in less than two years and put into operation late last year.

This plant, located on Ward's Island in East River near the mouth of Flushing Bay, is noteworthy in that it is the largest sewage treatment plant yet built in the United States. Some 11,000 acres, consisting of the eastern part of Manhattan from 72nd to 192nd Streets and a considerable portion of the Bronx having a population of 1,250,000 are tributary to the Ward's Island Plant. The ultimate sewage flow will be 425 mgd.

To bring the sewage to the plant required two deep under water crossings. In the crossing from Manhattan to Ward's Island construction was started with a minimum of exploratory work and from opposite shores. As the tunneling progressed, difficult material was encountered that prevented further tunneling. After an extensive program of borings, it was determined that the poor material could be avoided at a depth of 425 ft. under the river. Shafts were dropped from the portions of completed tunnels and the crossings made at this tremendous depth. After crossing the river in this inverted syphon, the sewage must be raised about 60 ft. in the pumping plant on Ward's Island.

We were impressed by the casualness with which eastern engineers pump large quantities of sewage against heads of forty or more feet. This we noted at Columbus, Ohio and Chicago, Illinois; as a matter of fact, all are equipped with pumps of tremendous capacity. The pumps at Ward's Island have a capacity of 90 mgd each.

*Chief, Bureau of Sanitary Engineering, State of California.
†Consulting Sanitary Engineer, San Francisco.

I was struck with some of the developments which we could trace in their beginning to some of the things we did in the west some years ago. This plant, which is an activated sludge plant, as in the plants at Columbus and Chicago, uses the big centrifugal blowers. The prototype of these blowers are the ones Harry Hommon and I had the temerity to put in. Ours were not too satisfactory because the gears built to stand high speeds, proved inadequate but they were the beginning of centrifugal blowers. George Gascoigne put them in one of his plants so we had a little company in our experience. These blowers which were developed by the General Electric Co. and subsequently by Ingersoll-Rand Co. and another type developed by Elliott Co. are the types of blowers used in the modern activated sludge plants which I visited.

We were impressed with the freedom with which all types of mechanical control are installed, particularly expensive cone valves. They have no hesitancy about putting these electrically controlled valves in at all points in the plants. The control room is in itself a marvel. There is only one other control room I saw on this trip, that at the River Rouge Power Plant at Dearborn, which compares with the control room at Ward's Island.

The problem of handling screenings and sand is taken care of on the inlet end of the inverted syphon across East River. Slides show these processes which Mr. Gillespie may explain more completely.

On the primary clarifier last January there was a very thick and troublesome scum that some of the experts who design skimmers would have had to tax their inqenuity to solve.

The activated sludge unit is standard except that the tanks are rather long. I believe the length of travel is 1300 ft., being a three pass through the plant.

The sludge is taken to the waterfront on the easterly side of Ward's Island and there elevated into great storage bins. Primary and excess activated sludge are mixed, loaded on to ships and carried to sea. Good size oil tankers take this sludge out into areas south of Long Island and discharge in an area set aside for this purpose. Mr. Donaldson, who is in charge of this plant, was very frank in many of the discussions. We asked him about the problem of stranding of this sludge and he said, "You know, they say Jersey City dumps in the same area and we have never been able to identify the sludge or establish responsibility." They have had considerable difficulty because they have had to rent boats to carry sludge to sea until just recently when their own boats were delivered. The difficulty is in getting the sludge discharged in such a way that it will sink. He was hopeful and quite optimistic that with their boats they would be able to get the sludge spread out and settled before it drifts ashore. The new ships spend an hour in discharging at the unloading area; with the old ships unloading required several hours.

If there is a problem connected with the operation of the plant I would say it was in the present manner of handling sludge. It is held

in these bins about six hours 60 ft. above ground. There is a large population living in the Borough of Queens immediately across from the loading place. Odor troubles may develop. Then there is the problem of so discharging the sludge at sea that complaint of stranding of sludge on the beaches is avoided.

One of the things that struck me was the elaborateness of all of the appointments around the plant, particularly applicable to their laboratory equipment. They are provided with special research laboratories, about four, in addition to regular routine laboratory in which samples go in at one end and follow through a series of tables to the other end. There are special incubator rooms and special rooms for other routine.

The whole plant is interesting because it produces a high grade effluent to be discharged into the East River practically at the outlet of Flushing Bay at the head of which is being built the New York World's Fair. This plant will undoubtedly help clean up the bay, but the Tallman Island plant yet to be built will have a greater effect. The Tallman Island is supposed to clean up Flushing Bay and make a fine recreational park of what was formerly an old ash dump by the time the fair opens.

Mr. Donaldson said there are still fourteen other plants to be constructed before the task of cleaning New York Harbor is complete. This gives an idea of the magnitude of the problem of caring for the sewage of seven to eight million people.

Mr. C. G. Gillespie will describe the various units of the Ward's Island Plant illustrated by the slides.

SAN DIEGO'S SEWER PROBLEMS

By FRED RHODES*

Every city in California has, I presume, its own problems in connection with the handling of its sewage. Such problems have required a great deal of study by the individual responsible for solution, or still cause worry as to how much longer the solution may be postponed. Every city has some problems peculiar to itself; but in this regard, I believe San Diego, due to its history and topography, stands unique.

Our old Mission, as most of you probably know, was founded and the Presidio established before the Revolutionary War. Although there was no influx of "tourists" until about the time of the gold rush of 1849, the community gradually grew, first, around what is now known as "Old Town," later, moving down to the present business district, and then expanding until now we have a population estimated at over 170,000.

Our first sewer system was constructed in 1887 and 1888 under the direction of Col. George E. Waring, consulting engineer of Newport, R. I. Most of these original sewers are still in use after 50 years of

*Director of Public Works, City of San Diego, Calif.

service, although it has been necessary to install several larger and deeper trunk lines through the down-town district from time to time.

Since disposal in the ocean or bay was such a relatively simple matter, as the city grew and new districts were developed, trunk lines were carried down the canyons and new outfalls constructed at convenient locations, until at the present time, we have a total of 22 outfall sewers, 9 of which empty into San Diego Bay, 1 into Mission Bay and 12 into the Pacific Ocean. These are scattered over about 15 miles of shore line between National City and LaJolla.

We have approximately 525 miles of main sewers, ranging in size from 6- to 24-in. in diameter, about 200 miles of which are vitrified clay pipe and the remainder chiefly concrete pipe.

One of the most serious problems confronting us is, of course, that of disposal and clearing up the waters of the bay. Mr. Phelps will tell you of our plans for handling this.

Another problem of great magnitude and involving an enormous outlay of funds in its solution, is that many of our trunk line sewers, installed some 25 years or more ago, are now running practically at capacity flow in normal times. In times of heavy rain, these sewers are over-taxed and, in some instances, the sewage has backed up into residences, causing damage to private property. San Diego employs the "separate system" and storm water is not **supposed** to enter our sewers; but, nevertheless, a large amount of the drainage from roofs and courts does find its way into the sewers in addition to that which enters from the alleys and gutters through manhole tops.

The worst of such cases are handled from maintenance funds as they develop. We have at present a city-wide W.P.A. project for cleaning and rehabilitation of sewers, but the need is so great that all of this work merely scratches the surface of our trouble along this line.

A large district outside the city, in the Kensington and Talmadge Park district, was permitted to discharge its sewage into our lines several years ago. This grew very rapidly into a high-class residential district, and most of it has since been annexed to the city. This additional load has overtaxed the trunk lines and the outfall sewer to which it is connected. The Kensington Sanitary District, while connected with our system, is still not a part of the city, although completely surrounded by territory which has annexed to the city. The residents of a portion of the city lying beyond the Kensington Park Sanitary District are still being charged for the use of the trunk sewer installed by the district.

The trunk sewer on Pacific Highway in the vicinity of the new City-County building is flooded with water from the bay at high tide. We are contemplating the installation of pumps to keep this line clear, before the building is put in use.

Another source of trouble to our maintenance crew is the stopping of ocean outfalls by shifting sand bottom. Most of our outfalls extend into deep water and seldom become clogged, but we have experienced considerable grief with the one at Mission Beach. The system at Mis-

sion Beach consists of a long collecting line of 10- and 12-in. sewer on a very flat grade, with three lifts in the line. The line was originally constructed of concrete pipe, mostly below the ground water level. There has been a great deal of infiltration of salt water carrying fine sand in suspension. About twice a year, the sewers had to be flushed and dragged to remove the deposit of sand. The salt water infiltration and the septic sewage, due to long retention in the sumps and the flat sewers, produced sulphides which caused disintegration of the upper portion of a large part of the trunk line. We have found it necessary to replace most of this trunk line in the last two or three years.

When trouble was first encountered in the outfall, it was cleaned only with considerable difficulty and at great cost; but after a few times, a new method was tried and proved very successful. A hole was cut in the outfall at the shore end and a 3-in. jet line inserted and gradually worked down to the outlet end. This was found to remove the sand at a small fraction of the cost of the methods previously tried and has been employed since at intervals of about 18 months.

We have had but one serious gas explosion in our sanitary sewer system, which occurred at the Imhoff tank at Beacon Street and West Point Loma in June, 1927. An accumulation of gas in the tank was ignited, presumably by some burning rope tossed into a vent in the tank by an unknown individual. This tank was a heavily reinforced concrete structure and the entire roof slab was blown off and one bystander seriously injured.

The principal trouble confronting us at the present time is one of finances, and any suggestion as to a "painless" method of raising funds for sewer rehabilitation and extension will be welcoved.

PLANS ON FUTURE SEWAGE DISPOSAL OF SAN DIEGO

By A. D. PHELPS*

The beautiful land locked harbor of San Diego is being improved in many ways. The Harbor Department has a program to dredge deeper channels, using the soil to construct piers and fill low lands. This will make a wonderful harbor if and when a sewage disposal plant is constructed to eliminate the dumping of raw sewage into the Bay.

There are nine outfalls, seven of which empty 80% of the city's sewage, in an untreated condition, into the Bay. In addition, Chula Vista, National City and Coronado empty their sewers into the Bay.

The topographical features of San Diego will allow the entire Bay to be circled by an interceptor sewer of sufficient size to carry all of the effluent to a central treatment plant. This would extend from Point Loma to a point near the Destroyer Base. The branch line would extend

*Assistant City Engineer, City of San Diego, Calif.

up Mission Valley and another line up the east side of Mission Bay. These would join the main trunk line at a point near the Marine Base.

The district north of Mission Bay to La Jolla would be served by a separate trunk line and treated at an independent plant up Rose Canyon east of the state highway.

Pumping plants would be required at various points along the line. These would be automatic plants with variable speed motors to develop a system of pumping that will vary with the flow. Coarse bar screens will be installed at each pumping house.

The City of San Diego has several methods of sewage treatment in mind. The most practical and economical for the immediate use would be plain sedimentation. This would be accomplished by clarifiers arranged so that chemical treatment could be added later. The settling out of about 70% of the solids and then discharging the effluent through multiple submerged outlets into the new channel would solve the problem to a large degree.

If water continues to be at a premium, it is very possible that another unit of treatment will be added and the effluent used for irrigation in Balboa Park and in orchards south of San Diego.

The city engineer has on file in the office a complete set of plans for all the trunk lines. These would be subject to revision before final plans could be sent out for bids. The plan would be broken into useful units and completed under different periods, thus limiting the amount required for each bond issue.

The plans for the sewage treatment plants being of a specialized design, it would be the best procedure to have competent sanitary designing engineers submit data and costs of construction and operation of successful plants of a similar nature. The actual construction drawings for both the trunk line system and for the treatment plants could then be drawn up in the city engineer's office. The personnel of that office, having the local conditions at hand and future operations in mind, would benefit by outside experience and the combination should produce a workable system.

Financing of the future sewage disposal plant has been the stumbling block. The cost of the construction would be about $3,500,000 for most of the lines and the cheapest type of a treatment plant to handle 20 mgd. The operation costs per year would also have to be considered.

The advantage of Government funds to supplement a bond issue of local assessments at this time has been considered, but due to the fact that almost every district in the City is suffering from an over-dose of improvement bonds, some opposition is sure to arise if a bond issue is proposed. Several attempts have been made to interest the U. S. Government departments in this important problem due to the fact that the outfalls are particularly situated at government bases and considerable sewage originates at government establishments. These are all pending, and until the finances are arranged for, engineering design and construction will be deferred.

ROSTER
CALIFORNIA SEWAGE WORKS ASSOCIATION MEMBERSHIP
(As of July 1, 1938)

Adams, Allen A.
Sterling Electric Motors
2900 Midwick Drive
Alhambra, Calif.

Albers, J. C.
City Engineer
City Hall
Glendale, Calif.

Alexander, C. F.
Operator Corona
706 Harris St.
Corona, Calif.

Allen, William A.
Supt. Pasadena Sewage Disposal Plant
City Hall
Pasadena, Calif.

Arndt, Charles
Plumbing and Heating
110 Winston Street
Los Angeles, Calif.

American Cast Iron Pipe Co.
55 New Montgomery Street
San Francisco, Calif.
Attn: W. R. Blair

Anaya, Marvin
San. Engr. Designer
367 City Hall
San Francisco, Calif.

Arnold, G. E.
San Francisco Water Dept.
Millbrae, Calif.

Banks, Harvey O.
1811 Fulton
Palo Alto, Calif.

Banta, A. Perry
Assistant Engineer
110 South Broadway, 4th Floor
Los Angeles, Calif.

Barnard, Archer F.
Quinton, Code and Hill
Leeds and Barnard
601 West 5th Street—Suite 905
Los Angeles, Calif.

Barr, H. R.
Operator Hyperion Screening Plant
Route 1, Box 302
Redondo Beach, Calif.

Bates, John S.
Consulting Engineer
3134 Eton Avenue
Berkeley, Calif.

Batty, F. A.
745 City Hall
Los Angeles, Calif.

Beale, Ed.
Director, Bureau of Sanitary Engr.
City Hall
San Diego, Calif.

Beard, Paul J.
Prof. Stanford University
Civil Engineering Dept.
Stanford University
Palo Alto, Calif.

Beardsley, C .W.
Bureau of Standards
City of Los Angeles
1827 Park Ave.
Los Angeles, Calif.

Bell, Alexander
Western Sales Manager
Wallace and Tiernan Company
171 Second Street
San Francisco, Calif.

Bell, R. H.
Operator
1300 Pennsylvania Ave.
Colton, Calif.

Benas, Ben
Sanitary Engineer
286 City Hall
San Francisco, Calif.

Beyer, A. Carl
District Manager
Wallace and Tiernan Company
171 Second Street
San Francisco, Calif.

Bishop, H. N.
Consulting Civil Engineer and City Engineer Sunnyvale and Willow Glen
P. O. Box 587
Sunnyvale, Calif.

Blackman, J. W. B.
City Engineer—Director Public Service
City Hall
Long Beach, Calif.

Bowen, M. R.
Sewer Supt.
205 North Greenleaf
Whittier, Calif.

Bowlus, Fred D.
Resident Engineer
Los Angeles County Sanitation Districts
110 South Broadway—4th Floor
Los Angeles, Calif.

Brea, City of
City Hall
Brea, Calif.

Brown, Kenneth W.
Sanitary Engineer
California Water Service Co.
829 North Monroe Street
Stockton, Calif.

Brown, Reuben F.
745 City Hall
Los Angeles, Calif.

Buck, J. H.
Street Superintendent
516 Santa Barbara Street
Santa Paula, Calif.

Buckingham, Earl M.
Draftsman, City of Oakland
96 Zinn Drive
Oakland, Calif.

Burnson, Blair I.
Asst. Sanitary Engr.
E. B. M. U. District.
512—16th St.
Oakland, Calif.

Burt, Austin
City Service Manager
City Hall
Ontario, Calif.

Byxbee, J. F.
City Engineer
City Hall
Palo Alto, Calif.

Castello, W. O.
Assistant Engineer, Division of Water
112 City Hall
Sacramento, Calif.

Castro, Albert J.
Supt. of Sewage Disposal Plant
724 Benton Street
Santa Clara, Calif.

Chamberlain, L. H.
District Manager Water Works
Supply Co.
417 South Hill Street
Los Angeles, Calif.

Chiarolla, Frank Vito
Student U. of C.
854 North Figueroa St.
Los Angeles, Calif.

Church, C. B.
Sales Engineer
Fairbanks-Morse and Co.
2015 North Main St.
Santa Ana, Calif.

Clark, J. C.
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603—14th Street
Huntington Beach, Calif.

Clark, John A.
2644 Dwight Way
Berkeley, Calif.

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San Francisco, Calif.
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Collins, A. Preston
Engineer County Surveyors Office
400 Klinker Building
Los Angeles, Calif.

Compton, C. R.
Office Engineer
L. A. County San. Dists.
110 South Broadway—4th Floor
Los Angeles, Calif.

Cook, Lawrence H.
Chemical Engineer
Sec. Menlo Park San. Dist.
Box 696
Menlo Park, Calif.

Cook, Max E.
Pacific Lumber Company
100 Bush Street
San Francisco, Calif.

Cooley, E. C.
Chicago Pump Co.
625 Market St.—Rialto Bldg.
San Francisco, Calif.

Cortelyou, H. P.
Engineer Disposal of Wastes
City Hall Room 606
Los Angeles, Calif.

Crane, H. R.
Owner, Flexible Sewer Rod
Equipment Co.
622 East 4th Street
Los Angeles, Calif.

Creears, Tom H.
Chicago Pump Company
1824 South Hope Street
Los Angeles, Calif.

Currie, Frank S.
Consulting Engineer
219 Andreson Bldg.
San Bernardino, Calif.

Dakan, Earl W.
U. S. Public Health Service
3093 Life Science Bldg.
Berkeley, Calif.

Daley, A. C.
Operator
1191 North Los Robles Ave.
Pasadena, Calif.

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2901 Los Feliz Blvd.
Los Angeles, Calif.

Davidson and Fulmor
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3746 Seventh Street
Riverside, Calif.

DeMarini, Frank E.
Water Purification Engineer
San Francisco, Water Dept.
Millbrae, Calif.

Derby, Ray L.
Asst. Sanitary Engineer
Dept. of Water and Power
207 South Broadway
Los Angeles, Calif.

Dommes, Sid F.
244 Fifth Street
Richmond, Calif.

Donaldson, David
1537 N. E. 13th Avenue
Portland, Oregon

Eastman, T. F.
Drainage Design Engineer
701 City Hall
Oakland, Calif.

Ellinger, Morris
Assistant Engineer
Lake Arrowhead, Calif.

Ely, H. M.
Chief Operator Disposal Plant
City Hall
Ontario, Calif.

Fairbanks, E. G.
Health and Safety Commission
City of Manteca
Box 66
Manteca, Calif.

Fairbanks, Morse and Co.
2401 Santa Fe Ave.
Los Angeles, Calif.
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Farley, L. C.
Consulting Engineer
746 City Hall
Los Angeles, Calif.

Fiscus, A. E.
Operator Terminal Island
1547 Ravenna Ave.
Wilmington, Calif.

Fitch, T. A.
Director Bureau of Standards
City of Los Angeles
826 Yale Street
Los Angeles, Calif.

Foreman, Merle S.
Bacteriologist-Chemist
3093 Life Science Bldg.
Berkeley, Calif.

Foster, Herbert B. Jr.
Sanitary Engineer
377 Coventry Road
Berkeley, Calif.

Fraser, A. F.
Chief Plant Operator
Golden Gate Park Plant
300A Carl Street
San Francisco, Calif.

Frick, A. L. Jr.
Wallace and Tiernan Co.
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Los Angeles, Calif.

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City Engineer
City Hall
Oakland, Calif.

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City Engineer
City Hall
Pomona, Calif.

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Wallace and Tiernan Co.
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Los Angeles, Calif.

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Consulting Sanitary Engineer
1140 Leader Bldg.
Cleveland, Ohio

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City Hall
Roseville, Calif.

Gillespie, C. G.
Chief, Bureau of Sanitary Engr.
State Dept. of Public Health
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Goodridge, Harry E.
City Engineer
City Hall
Berkeley, Calif.

Goudey, R. F.
Sanitary Engineer—Water and
Power Dept.
Box 240 Arcade Annex
Los Angeles, Calif.

Grant, Arthur J.
Assistant Operator
621 Thalia Street
Laguna Beach, Calif.

Grahek, Joe
171 Second Street
San Francisco, Calif.

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Consulting Sanitary and
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Assistant Engineer
City Hall
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City Engineer
City Hall
Lodi, Calif.

Henry, B. F.
Chief Operator Sewage Plant
P. O. Box 286
Pomona, Calif.

Hill, Chas. L.
City Engineer
Box 4
Reno, Nevada

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Park Engineer
National Park Service
Yosemite, Calif.

Hitchner, A. H.
Engineer, Oliver Filters, Inc.
351 California Street
San Francisco, Calif.

Holfelder, J.
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26 City Hall
Bakersfield, Calif.

Hommon, H. B.
Senior Sanitary Engineer
U. S. Public Health Service
112 Federal Office Bldg.
San Francisco, Calif.

Horton, F. C.
Operator Terminal Island
205—118th Place
Los Angeles, Calif.

Hoskinson, Carl M.
Chief Engr. Water Division
112 City Hall
Sacramento, Calif.

Huth, Norman A.
City Engineer
City Hall
Visalia, Calif.

Hyde, Charles Gilman
Prof. Sanitary Engineering
Room 11 Engineering Building
University of California
Berkeley, Calif.

Ikeda, T.
Director and Chief Engr.
Water and Sewage Board of
Nagoya Municipality
Nagoya, Japan

Ingram, Fred R.
826 Shattuck Ave.
Berkeley, Calif.

Ingram, William T.
Sanitary Engineer, San Joaquin
Local Health District
Box 111
Stockton, Calif.

Jacobson, John
Supt. of Repair and Power
University of Calif. Farm
Davis, Calif.

Jeffrey, H. H.
City Hall
Sacramento, Calif.

Jenks, Harry N.
Consulting Sanitary Engineer
2701 Benvenue Ave.
Berkeley, Calif.

Jennings, J. C.
Junior Engineer, Div of Water
112 City Hall
Sacramento, Calif.

Jewell, H. W.
Engineer, Pacific Clay Products
306 West Avenue 26
Los Angeles, Calif.

Jewett, Herbert A.
727 Arden Avenue
Glendale, Calif.

Jones, Thomas P. B.
County Sanitarian Agent
Health Department
P. O. Box 375
Riverside, Calif.

Jorgensen, Homer W.
County Sanitary Engineer
P. O. Box 1412
Modesto, Calif.

Kelly, Earl M.
Sanitary Engineer, Dorr Company
811 West 7th Street
Los Angeles, Calif.

Kempkey, A.
Consulting Engineer
1218 Hobart Building
San Francisco, Calif.

Kennedy, C. C.
Consulting Engineer
Atlas Bldg. 604 Mission Street
San Francisco, Calif.

Kennedy, Richard R.
Civil Engineer and Designer
Atlas Bldg.—604 Mission Street
San Francisco, Calif.

Kimball, Jack H.
Asst. Supt. Water and Sewer Div.
City of Palo Alto
120 Lorton Avenue
Burlingame, Calif.

Kivari, A. M.
Pacific Coast Manager—Dorr Co.
811 West 7th Street
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Knowlton, W. T.
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Lawton, Ralph W.
Consulting Engineer
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San Francisco, Calif.

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Mishimagun near Osaka—Japan

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May, Harold L.
1192 Briton Ave.
San Jose, Calif.

McBride, J. L.
City Engineer
City Hall
Santa Ana, Calif.

McMillan, John D.
City Hall
Newport Beach, Calif.

McMillan, Donald C.
City Manager, City of Ventura
121 South Coronado Street
Ventura, Calif.

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Camarillo State Hospital
Camarillo, Ventura County, Calif.

Meyer, Louis P. H.
Lt. Police S. F.
583 Dolores St.
San Francisco, Calif.

Miick, Fred E.
361 South Anderson Street
Los Angeles, Calif.

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Supt. Division of Water
112 City Hall
Sacramento, Calif.

Mooney, C. R.
Plant Operator
L. A. County San. Districts
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Compton, Calif.

Morrison, G. B.
Rm. 708 City Hall
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Munson, Laura A.
Sanitary Engineer
General Delivery
Lafayette, Calif.

Norman, Chas. S.
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El Segundo, Calif.

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Ojai, Calif.

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Wallace and Tiernan Company
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San Mateo, Calif.

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Monterey County
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San Francisco, Calif.

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San Francisco, Calif.

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L. A. County Sanitation Dists.
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Los Angeles, Calif.

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Assistant Engineer—City of L.A.
1924 Leman Avenue
South Pasadena, Calif.

Parsons, Francis W.
Assistant Engineer
City Hall
Los Angeles, Calif.

Patterson, Richard L.
City Engineer
City Hall
Newport Beach, Calif.

Peterson, J. H.
Staff Manager
Transite Pipe Dept.
Johns-Manville
116 New Montgomery
San Francisco, Calif.

Phelps, B. D.
Asst. City Engineer
City Hall—5th and G. Sts.
San Diego, Calif.

Phelps, Tracy I.
Engr. County Surveyor's Off.
400 Klinker Building
Los Angeles, Calif.

Pierce, C. L.
District Representative
Great Western Electro-Chem. Co.
1925 Euclid Avenue
San Marino, Calif.

Pleasanton, Town of
Pleasanton, Calif.

Pomeroy, Richard
Chemist—L. A. Sanitation Dists.
Box 353
Harbor City, Calif.

Polich, Theodore P.
Vice-Pres. United Conc. Pipe Co.
Box 1, Station H.
Los Angeles, Calif.

Popp, W. L.
City Engineer
City Hall
San Jose, Calif.

Porter, H.
Sewage Plant Operator
City Hall
San Mateo, Calif.

Porter, J. W.
100 Olive Street
Santa Cruz, Calif.

Post, Fred W.
Supt. Sewage Plant
Route 3, Box 433
Lodi, Calif.

Primmer, B. J.
District Manager
Amer. Conc. and Steel Pipe Co.
P. O. Box 13 Main Station
San Diego, Calif.

Qualls, Edward G.
Treatment Plant Operator
422 Palm Ave.
Whittier, Calif.

Ramseier, Roy E.
2811 Parker Street
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Ranagan, Fred E.
Pardee Engineering Company
823 West Fifth Street
Los Angeles, Calif.

Rantsma, W. Frank
Deputy Commissioner Pub. Wks.
City Hall
Fresno, Calif.

Rawn, A. M.
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L. A. County Sanitation Dists.
110 South Broadway—4th Floor
Los Angeles, Calif.

Reed, Charles A.
Engr. Plans and Specifications
City Hall
Oakland, Calif.

Reinke, Edward A.
Senior Sanitary Engineer
State Dept. of Public Health
3093 Life Science Bldg.
Berkeley, Calif.

Reynolds, Leon B.
Prof. Hydraulic and Sanitary Engr.
Stanford University
Palo Alto, Calif.

Ribal, Raymond R.
701 City Hall
Oakland, Calif.

Roberts, W. C.—Director
Pacific Engineering Laboratory
604 Mission Street
San Francisco, Calif.

Sanchis, Jos. M.
c/o American Consulate
Caracas
Venezuela, South America

Sauer, Victor W.
Draftsman
701 City Hall
Oakland, Calif.

Schaller, John E.
Relief Operator
L.A. County San. Dists.
159 W. 220th Street
Torrance, Calif.

Schapp, A.
Attorney
501 Hobart Building
San Francisco, Calif.

Senseman, Wm. B.
Pacific Coast Manager
Combustion Engineering Co.
406 South Main Street
Los Angeles, Calif.

Segel, A.
Consulting Engineer
1221 Mattei Bldg.
Fresno, Calif.

Shaw, Paul R.
c/o Fish and Game Commission
Ferry Building
San Francisco, Calif.

Shearer, A. B.
Marin Sanitary District No. 1
122 Tunystead Avenue
San Anselmo, Calif.

Shook, H. E.
Sales Dept.—Great Western
Electro-Chemical Co.
9 Main Street
San Francisco, Calif.

Singer, Lewis P.
Lincoln, Calif.

Skinner, John F.
Consulting Sanitary Engineer
3333 West 4th Street
Los Angeles, Calif.

Slane, Norman F.
Meter Service Inspector
Los Angeles, Dept. of Light
and Power
4425 Mont Eagle Place
Los Angeles, Calif.

Smith, Alva J.
Consulting Engineer
Black and Veatch
810 Boylston Street
Pasadena, Calif.

Smith, Frank E.
Operator Santa Ana
1100 E. Broadway
Anaheim, Calif.

Smith, H. G.
Engineer of Sewer Design and
Plant Operation
745 City Hall
Los Angeles, Calif.

Smith, J. F.
Vice-Pres. in Charge of Sales
Great Western Electro-Chem. Co.
9 Main Street
San Francisco, Calif.

Souther, Fred L.
Southern Machinery Co.
901 Union Street
San Diego, Calif.

Stevenson, Ralph A.
Stevenson Chemical Co.
641 Gibbons Street
Los Angeles, Calif.

Stites, Howard I.
City Engineer
272 North Olive Ave.
Burbank, Calif.

Strayer, Elmer C.
Civil Engineer
204 South Olive Ave.
Alhambra, Calif.

Stuart, Archer B.
City Engineer
City of Healdsburg
P. O. Box 21
Healdsburg, Calif.

Summers, William F.
Screening Plant Operator
10728 Westminster Ave.
Los Angeles, Calif.

Talbot, Frank D.
Consulting Civil Engineer
804 Forum Bldg.
Sacramento, Calif.

Taylor, Alva A.
2120 Cherry Ave.
Long Beach, Calif.

Tegtmeyer, L. G.
Sanitary Engineer
368 City Hall
San Francisco, Calif.

Tennant, Carl F.
Supt. of Operation—L. A. Co.
Sanitation Districts
216 Santa Fe. Ave. Apt. "B"
Long Beach, Calif.

Thews, Vernon W.
Operator Terminal Island
814 W. 98th Street
Los Angeles, Calif.

Thomas, Franklin
Prof. of Civil Engineering
Calif. Institute of Technology
Pasadena, Calif.

Toman, R. S.
Chief Chemist
Chemical Equipment Co.
Monadnock Building
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Pacific Clay Products
306 West Avenue 26
Los Angeles, Calif.

Wakeman, C. M.
Testing Engineer
1413 North Edgemont Street
Los Angeles, Calif.

Walters, Grover L.
Supt. Sewer and Water
123 West Wilshire Avenue
Fullerton, Calif.

Warren, A. K.
Chief Engineer
L. A. Co. Sanitation Districts
110 South Broadway—4th Floor
Los Angeles, Calif.

Weed, Sam A.
3875 Ruby Street—Apt. 308
Oakland, Calif.

West, Ezra, E.
City Electrician
308 North 10th Street
Colton, Calif.

West, Fred A.
422 East Jackson Street
Stockton, Calif.

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White, W. W.
State Sanitary Engineer
Nevada State Board of Health
Lyon Building
Reno, Nevada

Willette, C. R.
Chief Operator
National Park Service
Yosemite National Park, Calif.

Wilson, Twiford C.
Assisting Testing Engineer
Bureau of Standards L. A.
4608 W. Avenue 41
Los Angeles, Calif.

Wintersgill, A. T.
General Sales Manager
Pacific Clay Products Co
Box 145 Station "A"
Los Angeles, Calif.

Woodward, R. D.
Plant Operator and Mechanic
463 Myrtle Street
Laguna Beach, Calif.

Young, John T.
Principal Asst. Testing Engineer
City of Los Angeles
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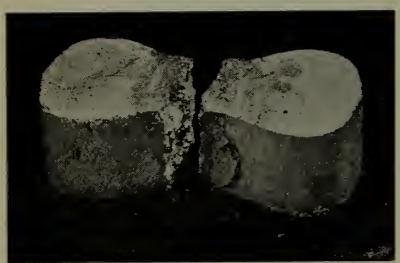
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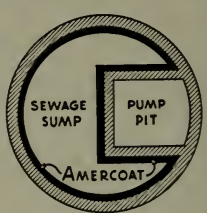
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IOWA CITY OPERATING DATA

(July through December 1937, inclusive)

Contributing population (estimated)	22,000	Solids Reduction—%	38.8
Raw Sewage Flow—m.g.d.	1.61	Volatile Matter Reduction—%	62.3
Raw Sludge to Digesters:		Digester Supernatant Liquor:	
Dry Solids—lbs. per day	3,240	Total Solids—%	0.20
Dry Solids—%	5.75	Suspended Solids—p.p.m.	330
Volatile Matter—%	62.2	Gas Production:	
Digested Sludge:		Average daily—cu. ft.	23,170
Solids—%	12.93	Cu. ft. per capita per day	1.05
Volatile Matter—%	38.3		

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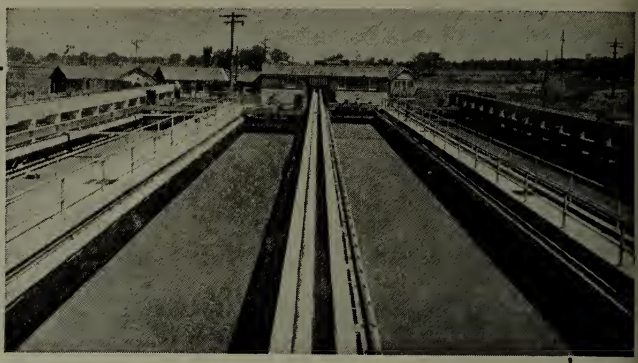
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CALIFORNIA SEWAGE WORKS JOURNAL

Official Publication of the California Sewage Works Association

Vol. XI :: 1939 :: No. 1

Minutes of the Eleventh Annual Fall Convention
At Santa Barbara, California
September 6 and 7, 1938

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Symposium on Pumps

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Remodeling of Old Plants

•

Conditioning and Sale of Sludge

•

Control of Chlorination

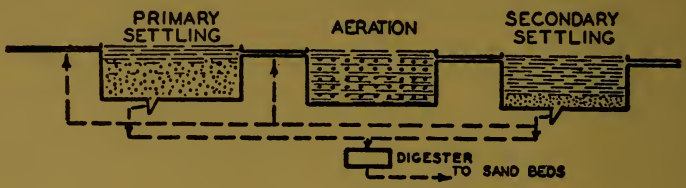
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Patents in Sewage Works Design

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Legal Aspects of Sewer Rental Laws

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California Sewage Works Journal

Published by CALIFORNIA SEWAGE WORKS ASSOCIATION

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ELEVENTH ANNUAL FALL CONVENTION

Santa Barbara, Calif., September 6 - 7, 1938

PROGRAM

Tuesday, September 6

Morning

7:30—Directors' Breakfast, Barbara Hotel Cafe.

8:00—Registration—Supervisors' Room, County Court House, Corner Anacapa and Figueroa Streets.

9:00—Business Meeting—Supervisors' Room, County Court House.

10:00—Symposium on Pumps
"Pumps in Sewage Works Practice," by Mr. W. M. Beadle, Byron Jackson Pump Company.
"Items to be Considered in Selecting a Pump," by Joseph Corrao, Supt. of Pumping Plants, San Francisco, Calif.
"Packings for Pump Bearings," by Bard Livingstone, Superintendent Municipal Water Dept., San Bernardino, Calif.

12:00—Luncheon—El Paseo Inn, Rotary Room.
Short Address: "Santa Barbara Harbor Problems," by Adolph Postel, Chairman, Board of Harbor Commissioners.

Afternoon

2:00—Reconvene, Supervisors' Chamber, County Court House.

2:10—"Remodeling of Old Plants to Increase Efficiency," by Jud Harmon, Asst. Sanitary Engineer, State of California.
Discussion Lead by:
F. S. Currie, Consulting Sanitary Engineer, San Bernardino, Calif.
C. C. Kennedy, Consulting Sanitary Engineer, San Francisco, Calif.

3:30—"Conditioning and Sale of Sludge for Fertilizer," by William A. Allen, Supt. of Sewage Disposal Plant, Pasadena, Calif.

4:15—"Control of Chlorination," by A. Carl Beyer, District Manager, Wallace and Tiernan Company.

5:00—Adjournment.

7:00—Banquet—El Paseo Inn, Rotary Room.
"Water Conservation, Santa Barbara County," by Hon. Alfred W. Robinson, Assemblyman.

Wednesday, September 7

Morning

9:00—Joint Meeting with Engineers' Section, League of California Municipalities—Chamber of Commerce Auditorium, 14 East Carillo.

9:10—"Patents in Design of Sewage Treatment Works," by A. Schapp, Patent Attorney, San Francisco.

10:00—"Legal Aspects of Sewer Rental Laws and Connections from Outside to City Sewer Systems," by Homer Buckley, Asst. City Attorney, Oakland, Calif.

11:00—"Disposal of Non-Polluted Waters from Cooling Systems," by Jean L. Vincenz, Commissioner of Public Works, Fresno, Calif.

Afternoon

1:00—Assemble for Caravan. Head of caravan will form on De la Guerra Street, east of Milpas Street.
1:15—Leave Santa Barbara for Ojai.
2:15 to 2:45—Inspect Ojai Plant.
3:15 to 3:40—Inspect Ventura Outfall.
4:00 to 4:30—Inspect Camarillo State Hospital Plant.

ANNOUNCEMENT OF ELEVENTH ANNUAL SPRING CONFERENCE CALIFORNIA SEWAGE WORKS ASSOCIATION VISALIA, CALIFORNIA APRIL 14-15, 1939

●

FRIDAY, APRIL 14, 1939

The morning of Friday, April 14 will be given to a short business meeting and discussion of the interesting facts concerning five recently completed plants in the vicinity of Visalia.

In the afternoon Prof. Charles Gilman Hyde will review the recent Report on "Sewage and Trade Waste Treatment" made by H. J. N. Hodgson of Adelaide, Australia. Many of Mr. Hodgson's observations are of more than ordinary interest to persons engaged in the sewage disposal field.

A paper "Occupational Health Hazards in Sewage Disposal Plants" by Dr. J. P. Russell, Chief, Industrial Hygiene Service of California should interest every operator as well as the engineers.

The subject "New Developments in Pipe for Sanitary Sewers" on which there will be several short papers will reveal some valuable new information and developments.

SATURDAY, APRIL 15, 1939

All day Saturday, April 15 will be a caravan visiting treatment plants at Visalia, Delano, Wasco, and if time permits Shafter and Bakersfield.

SPECIAL PROGRAM FOR THE LADIES

Friday, April 14 the ladies will motor to Sequoia National Park, enjoy lunch under the redwoods and return in time for the Annual Banquet.

ELEVENTH ANNUAL FALL CONVENTION
CALIFORNIA SEWAGE WORKS ASSOCIATION

Santa Barbara, California **September 6 - 7, 1938**

MINUTES OF MEETING

TUESDAY, SEPTEMBER 6, 1938

BUSINESS MEETING:

The Eleventh Annual Fall Convention of the California Sewage Works Association convened at the hour of 9:15 a. m. September 6, 1938, in the Supervisor's Room of the Santa Barbara County Court House with President Ray L. Goudey in the chair. Seventy-five were in attendance.

President Goudey announced the personnel of the Auditing Committee as W. T. Wintersgill, chairman; Roy Ramseier and H. M. Ely; and the personnel of the Nominating Committee as C. C. Kennedy, chairman; Earl Kelly and Carl Tennant. Mr. Tennant was not present, therefore the two first named members constituted the Nominating Committee. A call was made for reports of standing committees.

The Membership Committee report was made by Chairman Fred D. Bowlus, who stated that the Association had made a substantial gain in membership and that inclusive of dues collected at this meeting the membership had reached or exceeded 250.

Chairman J. F. Smith reported for the Committee on Financing of the Journal, saying that the two issues of the C. S. W. A. Journal published in 1938 were adequately financed.

Chairman A. M. Rawn, Legislative, reported that the committee's San Diego report covered the activity of the committee for 1938.

The following committee chairmen: Carl Beyer, Publicity; and Harold F. Gray, Certification and Schools; reported briefly upon their written reports printed elsewhere in this Journal.

The Secretary-Treasurer's financial report was read and referred to the Auditing Committee. The complete financial report, together with the report of the Auditing Committee, is published elsewhere in this Journal.

The Secretary reported briefly upon the principal items discussed by the Governing Board at breakfast earlier in the morning, namely, revision of the Constitution and By-Laws, relation of the Board of Control to the Governing Board, authorization for the formation of local sections and the introduction of items of interest occurring during the year into this Journal.

President Goudey announced that the Award Committee would make its report at the Banquet meeting.

Under new business: Harold F. Gray made a motion "That the incoming president appoint a committee to prepare a manual for sewage disposal plant operators and to make a preliminary report on the manuscript at the next Spring Conference," which was seconded by H. M. Ely. Passed unanimous.

Clyde C. Kennedy moved "That the incoming president appoint a committee to revise the Constitution and By-Laws." Seconded by Harold F. Gray. Passed unanimous.

After considerable discussion on the advisability of making the Board of Control members of the Governing Board, President Goudey requested a voice vote on referring the matter to the Committee on Revision of the Constitution and By-Laws. Favorable assent was given.

President Goudey called for the report of the Nominating Committee. Chairman Kennedy reported placing in nomination for President, Alexander Bell; for 1st Vice President, H. G. Smith; for 2nd Vice President, Harold F. Gray; for Director, Carl Tennant; for Board of Control, A. C. Beyer; and for Secretary-Treasurer, R. R. Ribal.

John Clark moved that nominations be closed. Seconded by James Parr. Passed.

It was then moved, seconded and passed that the Chairman be instructed to cast a unanimous ballot for all officers.

MORNING TECHNICAL SESSION:

There being no reply to the call for further business, President Goudey closed the business meeting and opened the Technical Session at the hour of 10:25 a. m. by calling upon Harold K. Palmer to read W. M. Beadle's paper on "Pumps in Sewage Works Practice." At the conclusion of Mr. Beadle's paper, Mr. Palmer passed around a small pump impeller and steel ball. Miraculously and to the surprise of many members, the ball went through the impeller punctuating Mr. Palmer's annotations by a clatter upon the floor. President Goudey announced that the subject of pumps would be opened for discussion after presentation of all papers thereon.

The second paper, "Items to be Considered in Selecting a Pump," in the absence of Joseph Corrao, was read by the Secretary. Bard Livingstone read his paper, "Packing for Pump Bearings."

Discussion on Pumps:

In reply to a statement that "split case pumps are not available in smaller sizes," W. A. Allen replied that to his knowledge (De Laval) split case pumps in 4 and 5 in. sizes are obtainable.

Mr. Rawn stated that instead of complicated pumping synchronism, suggested by the speaker, it might be easier to permit the pumps to come in and out at will and run the sewage flow through some sort of an equalizing tank or basin with a weir outlet which would head off excessive flows from the plant and permit a predetermined rate of feeding without reference to the short period pumping capacity.

Mr. Adams was asked to explain the workings of the variable speed pumping at Huntington Beach and replied:

"The sewage pumps at Huntington Beach are driven by vertical variable diameter V-belt pulley drives. The entire drive including constant speed induction motors is built as a unit.

"The speed is changed by means of a float located in the wet well, and as the rate of the flow changes, the float raises or lowers and makes

contact in a control box which starts a control motor increasing or decreasing the speed of the pump to the exact speed required to pump the sewage at its incoming rate.

"The variable speed drive will change from minimum to maximum speed with about a 12 in. increase in level of sewage in the wet well."

Mr. Pomeroy added, "There is an important advantage in variable speed pumping which should not be overlooked. That is, it permits pumping sewage out of a wet well practically at the same rate it comes in. This in turn allows the construction of smaller wet wells and avoids retaining sewage until it becomes septic."

Mr. Kennedy's remarks were as follows:

"I want to emphasize the importance of the recent developments in sewage pumping ahead of sewage treatment plants, to provide for continuous pumping at rates which closely approximate the rate of sewage flow into the pumping plant. In earlier periods we have failed to recognize the very serious loss of efficiency in settling tanks due to high rate, intermittent pumping. Not only does high rate, intermittent pumping produce an overflow rate far higher than the average and, usually, far higher than the rate necessary for good removals of settleable solids, but the sudden surges set up in the tank produce local currents which carry out of the tank, material which has already subsided.

"California manufacturers are to be commended for the development of the automatically float controlled variable speed drive which gives almost complete flexibility to pumping where moderate size units are sufficient to meet the requirements. In the design of a pumping unit for the Bakersfield, California, sewage treatment plant, we have been able to secure almost perfect flexibility with one constant speed and two variable speed drive motors for a flow varying from 3.5 m.g.d. to 7 m.g.d. with one constant speed duplicate for reserve."

Mr. Palmer, in reply to Mr. Kennedy, said, "The use of variable speed for pumps is almost ideal, not only from an operating standpoint, but from power economy as well, as it takes less power to pump a given amount of water through a pipe slowly than to do it fast. The vari-drive is more efficient than the slip ring motor because of the power wasted as heat in the grids of the latter, but unfortunately up to the present time vari-drive is not available for motors larger than 15 h.p. For larger installations it is necessary to use slip ring motors. The power required varies approximately as the cube of the speed so there is a power saving even after deducting the loss in the grids. These grids are furnished by electric manufacturers for two classes of service: (1) machine tool in which the torque is constant for all speeds, and (2) fan service, in which the torque is proportional to the square of the speed. It is essential that fan service be designated for the grids to be used with pumps as the grids for machine tool service will not give the variation required when used on pumps. Supplying the wrong type involves the inconvenience and cost of changing grids. Lately the Los Angeles County Sanitation Districts installed a pump with a slip ring motor to handle 10,000 g.p.m. at 8.5 ft. total head of which 7.0 ft. was static, when the pump was run-

ning at full speed. In this case varied speed was required to accommodate differences in flow and in static head. After the pump was selected a computation was made of the relation between the brake horse power and the speed, taking into account changes in static lift, quantity pumped and efficiency at the various points involved. This relation was given to the electric company to be used in the design of the grids and the result was very satisfactory. This is a computation which should be made by the designing engineer because he is better acquainted with the actual conditions to be encountered than anyone else.

"Regarding the size of the wet well to avoid excessive detention, the Los Angeles County Sanitation Districts have adopted a criterion of storage capacity equal to five minutes flow of the largest pump. The shortest cycle will occur when the inflow is half the capacity of the pump, when ten minutes will be required to fill and ten minutes to empty, or twenty minutes in all. More or less inflow will lengthen the cycle. If two or more pumps are to operate in parallel, one (or more) running continuously while one cuts in and out, those running continuously will not affect the storage capacity as the water they handle goes out as fast as it flows in, so storage need be supplied only for the one running intermittently."

Mr. Phelps, speaking about cramped conditions in pump wells, expressed his opinion that ample room for packing and greasing of pumps is most essential to proper functioning and avoidance of shut downs.

Mr. Ribal cited an example of the inaccessibility of drainage pumps for an underpass in Oakland. The drainage pumps are installed in the wet well about 25 ft. below the motors. The long vertical shafts were not rigidly supported and as a result whipped so badly that the pump runners were thrown off. There is about a 3-ft. square opening to the wet well, no provisions for lighting and dismantling of the pumps had to be accomplished in about 2 ft. of water.

John Clark called attention to a flush clean pump.

The three above mentioned papers forming a symposium brought out considerable more discussion on the subject of pumps than your Secretary could record and which discussion unfortunately had to be terminated for the noon recess.

LUNCHEON MEETING:

There were seventy-seven in attendance at the luncheon meeting held in the Rotary Room of El Paseo Inn. After introducing those at the head table, President Goudey presented Adolph Postel, Chairman of the Board of Harbor Commissioners, who gave a short address on Santa Barbara's Harbor Problems. He said in part, that the Santa Barbara breakwater was constructed in 1927-1928 at a cost of $750,000 raised through public and city contribution, although the construction had been disapproved five times between 1873 and 1921 by government investigating engineers. The purpose of the harbor was to create quiet water for small craft. All factors, including shore currents, were not thoroughly studied by the engineers with the result that an estimated 3,000,000 cu. yd. of sand has become entrapped within the harbor and

the beaches starved of littoral drift for ten years have become barren of sand for a distance of ten miles, and those as far as fifteen miles easterly have been affected.

It has been estimated that the removal of the breakwater might cost in excess of $750,000. Faced either with the removal of sand from the harbor or have the harbor fill, a plan worked out by the District Engineer was adopted this year and 700,000 cu. yd. of sand pumped from the harbor onto the beaches. The restored beaches have an average width of 60 ft. and a fore shore of 250 to 300 ft. Mr. Postel said the problem had not yet been solved, for it remains to be determined how the reconstructed beaches will withstand the attack of a winter, how long they will last and how far easterly the beaches will be benefited. In closing, he hoped, that since there has been plenty of grief and loss of tourist trade on account of the breakwater, that when sewage disposal was undertaken it would receive careful consideration.

AFTERNOON TECHNICAL SESSION:

The afternoon session was called to order at the hour of 2:15 p. m. by President Goudey in the Supervisor's Chamber of the County Court House. There were 80 in attendance at the opening of this meeting and this number soon reached the 100 mark.

In the absence of Jud Harmon, his paper "Remodeling of Old Plants to Increase Efficiency" was read by the Secretary. C. C. Kennedy presented his discussion of Mr. Harmon's paper and the Secretary read the discussion prepared by F. S. Currie.

Mr. Pomeroy moved that a committee be appointed to set up recommended standards for sewage treatment plant design. Seconded.

Mr. Gray, in discussing the motion, said there is no information to standardize, sewage is a variable material, each community presents different problems; therefore if rules could be established, there would be danger in their too rigid enforcement.

Mr. Banta added a little zest to the meeting with the remark: "The key to this convention seems to be let us write a book. The only constant of sewage is its variation."

Mr. Ramseier, suggested that the committee might be a fact finding one instead of one to draw up recommendations, since the facts are necessary before the making of recommendations.

Mr. Knowlton expressed a belief that the recommended standards might be all right for the use of engineers, but there was a possible danger in their use by others.

Mr. Phelps spoke of the loss of Federal money for sewage disposal because an attempt was made to decide on the type of treatment before the voting of bonds. If recommended standards were available, he indicated, a plan might have been approved, bonds voted and the Federal contribution saved.

Mr. Rawn expressed the opinion that a book of design standards is dangerous.

In view of the discussion, Mr. Pomeroy asked permission to restate his motion and on consent of the second, restated it as follows: "That the Governing Board of this Association set up a Fact Finding Com-

mittee on Standards to confer with the American Society of Civil Engineers, to study factors in sewage treatment plant design, and to recommend these factors to the State Board of Health." Seconded. Carried.

It was moved, seconded and passed that an appropriate resolution be sent the Board of Supervisors of Santa Barbara County for the use of the meeting room. The pleasantness, decorations and furnishings of this room added considerably to the enjoyment of the meetings.

Wm. A. Allen presented his paper on "Conditioning and Sale of Sludge for Fertilizer," covering experiences at Pasadena where the sale price of sludge fertilizer has varied considerably. While a net revenue is not obtained from sludge fertilizer, the revenue therefrom appreciably reduces the cost of sludge disposal.

The last paper of the session, "Control of Chlorination," was read by the author, Carl Beyer. This paper presented some of the new developments in the field of chlorination.

The last two papers mentioned above were not discussed, due partly to lack of time and partly to limited application in California or newness of the information presented.

The meeting adjourned at 5:10 p. m.

BANQUET MEETING:

The banquet meeting was held in the Rotary Room of the El Paseo Inn. The attendance was 110. The speaker of the occasion was the Hon. Alfred W. Robinson, Assemblyman, who presented most concisely the problems of "Water Conservation in Santa Barbara County."

The entertainment consisted of Spanish song and dance accompanied by a Spanish orchestra. A nationally recognized sleight of hand artist performed many mystifying tricks, some perhaps still wonder how the name California Sewage Works Association was torn into the paper lace work.

Harold L. May, in the absence of W. R. Willette, chairman, reported for the Award Committee. The first award, a bronze plaque, was made to the Ontario Plant. H. M. Ely, the chief operator, received the cash award of $25.00. The second and third awards, due to lack of supporting data and absence of operators from the convention, were not made.

WEDNESDAY, SEPTEMBER 7, 1938.

MORNING TECHNICAL SESSION:

The Eleventh Annual Joint Session of this Association with the Engineers Section of the League of California Municipalities was called at the hour of 9:00 a. m. in the Chamber of Commerce Auditorium by Clarence J. Shults, President of the Engineers Section, and after extending a welcome from his organization to the California Sewage Works Association, turned the gavel over to President Goudey, who then presided.

A count of the attendance revealed 120 present.

Mr. Goudey replied to Mr. Shults' welcome as follows:

"Mr. Shults, members of the Engineers Section, friends: Each year

we try to suggest something practical to carry on our joint activities throughout the year. This year I thought of nothing better than to request of you who are city engineers, that you determine if your sewage treatment plant operator is a member of the California Sewage Works Association, and if not a member, to suggest that he become a member.

"There are too many cities having sewage treatment plants, the operators of which have not been privileged to attend these conventions and therefore have not profited by the exchange of opinions that takes place. Although the California Sewage Works Association is a separate organization, it is directly and officially a part of the League, so with that close familarity, kindly arrange for your treatment plant operator to attend these meetings.

"An outstanding accomplishment of our Association during the past year and a half is the certification of operators into three grades, according to experience and educational requirements. At this date, 107 operators have been voluntarily certified under regulations adopted by the California Sewage Works Association. I mention this to indicate that this Association is a going concern and that every operator should be a member."

Mr. Goudey prefaced his introduction of the first speaker with the remarks: "The first paper this morning deals with a very troublesome problem. No matter how new a thing you attempt to design, it may have been used at one of the hundreds of operating sewage treatment plants and you are infringing on someone's patent. Some of the litigations that are now going on and others in the offing are likely to be quite embarrassing to the engineering profession in general. We, therefore, thought it would be of interest to have a paper before this joint session on the subject 'Patents in Design of Sewage Treatment Works' and have fortunately obtained Mr. A. Schapp, patent attorney of San Francisco."

Mr. Schapp read his paper which was so complete and concise that when the meeting was opened for discussion, no one chose to question or add to his text.

Mr. Goudey: "We will then pass on to the second paper 'Legal Aspects of Sewer Rental Laws and Connections from Outside to City Sewer Systems.' A speaker has been selected who is closely allied with and an authority on the subject, therefore can give us some mighty good advice. I take pleasure in introducing Homer Buckley, Assistant City Attorney of Oakland."

Mr. Buckley spoke extemporaneously upon the announced subject. His words were recorded for editing and preparation for printing in the Journal. Mr. Buckley's remarks occasioned considerable discussion which is printed following his paper.

Mr. Goudey: "It is necessary to terminate this interesting discussion of Mr. Buckley's paper. I will declare a one minute recess before the presentation of the third and final paper."

Following the recess, Mr. Goudey said, "A great many cities have recently found that the large volumes of water required for aid condi-

tioning seriously taxing the capacity of city sewer systems. We have as the third speaker Jean L. Vincenz, Commissioner of Public Works of Fresno, a city confronted with the problem, and he, therefore, speaks from first hand knowledge."

Mr. Vincenz prefaced the reading of his paper with a story about Old Uncle Andy whom 83 cups of coffee a day helped to keep awake, referred to the nice comfortable folding chairs, thanked Mr. Goudey for declaring the short recess, and issued a warning to those blessed cities where aid conditioning is thought unnecessary, saying the presence of air conditioning elsewhere with its favorable advertising will make it necessary for competitive reasons, if not on account of weather conditions.

The discussion occasioned by Mr. Vincenz' paper is printed following his paper in this Journal.

The meeting place for the afternoon caravan, De la Guerra and Milpas Streets, was announced and the 11th Annual Convention adjourned.

AFTERNOON CARAVAN:

The caravan left Santa Barbara at 1:15 p.m. for Ojai, where a committee of the Junior Chamber of Commerce met the caravan at the City limits and conducted it to the treatment plant. The Ojai sewage treatment plant is an excellent example of the remodeling of an old plant to increase capacity and efficiency. On returning to the cars to continue the caravan, a generous helping of huge sweet Ojai oranges had been cached on the seat of each car, thanks to the hospitality and thoughtfulness of the Junior Chamber.

The Ventura screening and pumping plant was reached at 3:20 p.m. nearly on schedule. A mimeographed booklet was presented each member giving complete information on sewage disposal and an account of the destruction and replacement of the outfall.

The third plant visited was a bio-filtration plant at Camarillo State Hospital. This is one of the newer innovations in sewage treatment and because of the careful labeling of the various pumps, piping, valves, recorders, etc., a much better understanding of the method and principles involved was obtained.

The Caravan disbanded at Camarillo at 4:20 p.m.

Respectfully submitted,

R. R. RIBAL

Secretary-Treasurer.

AUSTIN BURT

On September 25, 1938 at the age of 68 years, following a heart attack, death claimed Mr. Austin Burt, City Manager of Ontario for the last ten years. Prior to coming to California, twelve years ago, Mr. Burt served as manager of the Waterloo Power and Light Company of Waterloo, Iowa. He was elected to the Board of Control of the California Sewage Works Association in 1937 and in this capacity served the Association well.

CALIFORNIA SEWAGE WORKS ASSOCIATION

Report of the Secretary-Treasurer Sept. 6, 1938

(Paid Membership to Date — 234)

BALANCE AS OF SEPT. 14, 1937		$ 634.24
CASH RECEIPTS:		
Membership Dues—1937	$ 34.00	
Membership Dues—1938	463.00	
Membership Dues—1939	4.00	
Journal Sales and Subscriptions	6.00	
Fees from Applicants for Certification	57.00	
Journal Advertising	457.50	
School for Operators	32.50	
Refund from Certification Account	29.25	
Cash on Hand	2.00	1,085.25
TOTAL RECEIPTS		$ 1,719.49
CASH DISBURSEMENTS:		
Printing-Mailing Jl. Vol. 9, No. 2	$266.38	
Printing-Mailing Jl. Vol. 10, No. 1	243.08	
Membership Dues, 1937	30.00	
Federation Sewage Works 1938	351.00	
Stenographic Service, Misc.	34.41	
Stationery, Printing, Stamps	123.91	
Engraving Certificates, etc.	43.39	1,092.17
CASH ON HAND Sept. 6, 1938		$ 627.32
ACCOUNTS RECEIVABLE:		
Great Western Electro Chemical Co.	$ 60.00	
Currie Engineering Company	10.00	
Clyde Kennedy	10.00	
Crane Company	30.00	
Wallace-Tiernan Company	75.00	185.00
OUTSTANDING BILLS:		
Printing of Jl. Vol. 10, No. 2	$267.80	
Mailing of Jl. Vol. 10, No. 2	12.00	
Printing of Programs	14.57	
Incidental Expenses Secretary	6.88	301.25
DEBIT OUTSTANDING as of Sept. 6, 1938		$ 116.25
BALANCE as of Sept. 6, 1938		511.07

REPORT ON CERTIFICATION OF OPERATORS ACCOUNT

(A Total of 107 Operators Have Been Certified)

FEES RECEIVED		$ 57.00
Engraving of Certificates	$ 10.00	
Envelopes—Seals, Etc.	4.14	
Mailing Certificates	12.75	
Mailing Preliminary Letter	13.50	
Incidental Postage	3.00	43.39
CASH BALANCE CERTIFICATION ACCOUNT		$ 13.61

REPORT ON SCHOOLS FOR OPERATORS ACCOUNT

Received from H. F. Gray		$ 32.50
Stamps Advanced	$ 7.50	7.50
CASH BALANCE SCHOOL ACCOUNT		$ 25.00

Respectfully submitted,

R. R. RIBAL

Secretary-Treasurer

REPORT OF THE AUDITING COMMITTEE

Santa Barbara, Sept. 6, 1938

This is to certify that we the undersigned Auditing Committee have audited the books and financial report of the Secretary-Treasurer, Mr. R. R. Ribal; also the financial report of Mr. Harold Gray and find them both to be in order and correct.

Signed:

A. T. WINTERSGILL, Chairman
R. E. RAMSEIER
H. M. ELY

REPORT OF PUBLICITY COMMITTEE, CALIFORNIA SEWAGE WORKS ASSN.

11th Annual Fall Convention

Santa Barbara, California, Sept. 6-7, 1938

During the year the Committee has arranged for publicity regarding members and activities of the Association. This publicity has been submitted regularly to *Western City, Western Construction News, Water Works & Sewerage, Municipal Sanitation,* and in certain cases such as the joint activities with the California Section of the American Water Works Assn., to Water Works Engineering and the Journal of the A.W.W.A. Likewise in certain cases publicity has been secured in local newspapers; the Committee is indebted to W. T. Ingram of Stockton and to R. E. Mittlestaedt of Sacramento, for aid in their respective communities in connection with newspaper publicity.

The following recommendations are submitted for the benefit of the next year's Committee:

1. Publicity should continue to be sent regularly to the magazines mentioned above. These publications are interested in and willing to print news both of the activities of the Association and associated activities of individual members.

2. Publicity for the Association can be secured from time to time in local newspapers, but it is essential that this publicity be tied in with the activities of some individual member who resides in the community to which the publicity is sent. It is also desirable if not essential that the submission of the publicity to the local newspaper to be followed up by somebody in that locality. Certification of Operators, attendance at Operators' Schools, etc., afford opportunities for this type of publicity.

3. Contacts with various fish and game associations are of value. The Associated Sportsmen of California have been contacted and it is felt that this group would be very glad to accept an offer from our Association to have a C.S.W.A. member serve on the Stream Pollution

Committee of said Association. It is recommended that a member of next year's Publicity Committee, to be designated by the Chairman of the Committee, be appointed to serve on the Stream Pollution Committee of the Associated Sportsmen of California, subject to approval of that group.

4. A map prepared by Ben Benas which shows the location and type of various sewage plants throughout the State, also the C.S.W.A. membership locations throughout the State, and streams which are and are not protected adequately by sewage treatment plants, is available for use both by next year's Publicity and Membership Committees.

The chairman is very appreciative of the assistance received from Messrs. Ben Benas, Earl Kelly and John F. Skinner, who served as members of the committee.

A. C. BEYER
Chairman, Publicity Committee
California Sewage Works Assn.

CALIFORNIA SEWAGE WORKS ASSOCIATION COMMITTEE ON SCHOOL FOR OPERATORS

REPORT ON SCHOOL HELD JUNE 22, 23, 24, 1938

At Berkeley, California

Mr. R. F. Goudey, President,
California Sewage Works Association,
Box 240, Arcade Annex,
Los Angeles, California.

Dear Sir:

We herewith present our report on the School for Sewage Treatment Plant Operators and Water Treatment Plant Operators conducted by this Association jointly with the California Section, American Water Works Association, and with the cooperation of the University of California, on June 22, 23, and 24, 1938.

This was the second school under the joint auspices of the two Associations, the first being held in Los Angeles in 1937.

In the organization of the course your committee had the benefit of the advice and counsel of an informal advisory group, selected by the Chairman of the Committee. This group met on three occasions prior to the school to advise on content and method of instruction, and their advice was most valuable. The members of the Advisory Group were:

G. E. Arnold, Chief Water Purification Engineer,
San Francisco Water Department,
Millbrae

J. I. Ballard, Editor
Western Construction News,
San Francisco

Paul J. Beard,
Assoc. Prof. of Sanitary Sciences,
Stanford University

Carl M. Hoskinson, Sect.-Treas.,
California Section, A.W.W.A.,
Sacramento

Charles Gilman Hyde,
Professor of Sanitary Engineering,
University of California,
Berkeley

William T. Ingram, Sanitary Engineer,
San Joaquin Local Health District,
Stockton

Alexander Bell,
Wallace and Tiernan Sales Corp.,
San Francisco
Benjamin Benas
Engineer of Design of
Sewage Treatment Plants,
City of San Francisco
A. Carl Beyer,
Wallace and Tiernan Sales Corp.,
San Francisco
Joseph D. De Costa,
Superintendent of Distribution,
East Bay Municipal Utility District,
Oakland
Dr. Walter M. Dickie,
State Director of Public Health,
San Francisco
Archie Fraser, Operator,
Golden Gate Park Sewage Treatment
Plant,
San Francisco
C. G. Gillespie, Director,
Bureau of Sanitary Engineering,
State Department of Public Health,
Berkeley
John S. Longwell,
Chief Engineer and Gen. Manager,
East Bay Municipal Utility District,
Oakland
Fred Miick,
Link-Belt Company,
Los Angeles
E. A. Reinke, Senior Sanitary Engineer,
Bureau of Sanitary Engineering,
State Department of Public Health,
Berkeley
Leon B. Reynolds,
Prof. of San. and Hyd. Engineering,
Stanford University
Raymond R. Ribal, Sect.-Treas.,
California Sewage Works Assn.,
Oakland
Dr. Milton Rose,
Assistant Director of the Curricula in
Public Health,
University of California,
Berkeley
A. B. Shearer, Manager,
Marin Sanitary District No. 1,
San Anselmo

In addition, we received valuable help and cooperation from Richard Graves, Executive Secretary, League of California Municipalities, and Winston Updegraff, Managing Editor of *Western City*. L. H. Kessler, Associate Professor of Hydraulic and Sanitary Engineering, University of Wisconsin, was most helpful in loaning material in relation to the Wisconsin school. We are indebted to the University of California for permission to use class rooms and laboratories, to John MacLaren, Superintendent of Golden Gate Park, San Francisco, for the use of the activated sludge plant for demonstration purposes, and to the East Bay Municipal Utility District for the use of the San Pablo Filter Plant for demonstration purposes.

The committee decided to issue no manual or reprint of lecture notes, as was done at the previous school, and to pay no honorarium to the teaching staff. Students in the Sewage Group were furnished at cost with a reprint of a series of articles on "Sewage Plant Operation" which had appeared in Municipal Sanitation. The fee for the course was set at three dollars ($3.00) payable in advance, as being sufficient to pay for the expenses of the school.

We had a total attendance of thirty-four (34) persons regularly enrolled, of whom fifteen (15) registered for the sewage treatment course, and nineteen (19) for the water treatment course. Of the fifteen enrolled in the sewage course, six were from the San Francisco Bay area, four were from San Joaquin Valley cities, three from Southern California, and two from Sacramento. The school was therefore not a local or Northern California school.

The instructional work was carried on according to the following schedule:

Wednesday, June 22, 1938

8:30 A.M. REGISTRATION—Room 3570 Life Sciences Building, University of California.

General Session

9:00 A.M. FUNDAMENTALS OF WATER TREATMENT

K. W. Brown, Sanitary Engineer, California Water Service Company, Stockton.

Chemistry of Water—Bacteria in Water—Coagulation and Filtration—Corrosion—Water Softening.

10:30 A.M. FUNDAMENTALS OF SEWAGE TREATMENT

Charles Gilman Hyde, Professor of Sanitary Engineering, University of California, Berkeley.

Physical, chemical and biological characteristics of sewage—Population equivalent of trade wastes—Uses and limitations of principal methods of sewage treatment.

1:30 P.M. PUMPS

Otto Zinke, Kimbal-Krogh Pump Co.

Selection of proper type of pumping equipment. Demonstration of proper care and maintenance of pumping equipment.

2:30 P.M. FLOCCULATORS, CLARIFIERS, ETC.

Earl M. Kelly, The Dorr Company.

The uses of mechanical equipment in screening, flocculating, and clarifying of water and sewage. Proper care and maintenance of such equipment.

3:30 P.M. CHLORINATORS

A. Carl Beyer, Wallace and Tiernan Sales Corp., San Francisco.

Types of chlorinators and their applicability. Demonstration of proper care and maintenance of chlorinating equipment.

4:30 P.M. ELECTRICAL EQUIPMENT

Geo. A. Webber, Palo Alto.

Fundamentals of electric power. Proper operation and maintenance of motor driven equipment and protective relays. Protection of persons from shock.

Thursday, June 23, 1938

Water Treatment Group

9:00 A.M. GROUND WATER SUPPLIES

Jeptha Wade, Chief Engineer, California Water Service Company, San Francisco.

Construction of the different types of wells, their sanitation and maintenance.

10:00 A.M. SANITATION OF THE DISTRIBUTION SYSTEM

G. E. Arnold, Chief Water Purification Engineer, San Francisco Water Department.

Sterilization of mains—Prevention and elimination of cross-connections—Protection of reservoirs.

11:00 A.M. FILTER OPERATING TECHNIQUE

Blair Burnson, Assistant Sanitary Engineer, East Bay Municipal Utility District, Oakland.

Operation and maintenance of filters and appurtenances, rate of flow controllers, hydraulic valves, gauges, chemical feeders, etc.

Sewage Treatment Group

9:00 A.M. MAINTENANCE OF SEWERS

R. R. Ribal, Secretary, California Sewage Works Assn., Oakland. Maintenance of sewers with special reference to its relation to the sewage treatment processes.

10:00 A.M. SLUDGE HANDLING AND DISPOSAL

O. C. Hopkins, Assistant Sanitary Engineer, United States Public Health Service.

Sludge digestion, heating, and sludge drying methods—Sludge withdrawing periods—Uses of dried sludge—Gas utilization.

11:00 A.M. DISPOSAL OF TREATED EFFLUENTS

Harold Farnsworth Gray, Lecturer in Public Health, University of California, Berkeley.

Effect of sewage effluents upon streams and upon land—Prevention of nuisance—Protection of health.

Water Treatment Group

1:30 P.M. CHEMISTRY AND BACTERIOLOGY OF WATER TREATMENT

Paul J. Beard, Assoc. Prof. of Sanitary Sciences, Stanford Univ. Laboratory demonstrations and discussions of chemical and bacteriological techniques used in sanitary water procedures—chlorides, dissolved oxygen, free chlorine, hydrogen ion concentration, alkalinity, hardness, etc. Indices of pollution.

Sewage Treatment Group

1:30 P.M. CHEMISTRY AND BIOLOGY OF SEWAGE TREATMENT

Edward A. Reinke, Senior Sanitary Engineer, Bureau of Sanitary Engineering, California State Department of Public Health, Berkeley.

Laboratory demonstration and discussions of relative stability, biochemical oxygen demand, hydrogen sulphide, settleable solids, sewage biology, etc.

General Session

3:30 P.M. LAWS PERTAINING TO WATER SUPPLY AND SEWAGE TREATMENT

Homer Buckley, City Attorney, Oakland.

Liability of city in operation of water treatment and sewage treatment plants—Responsibility of operators.

4:30 P.M. KEEPING OPERATING RECORDS

C. G. Gillespie, Chief, Bureau of Sanitary Engineering, California State Department of Public Health.

The value of operating records—What should be recorded—The kind of record—The uses of operating records.

Water Treatment Group

8:00 P.M. DISCUSSION OF OPERATORS' SPECIFIC PROBLEMS

Operators were requested to submit their particular difficulties and problems, in writing, in advance. These problems were discussed by a panel consisting of G. E. Arnold, K. W. Brown, C. G.

Gillespie, A. C. Beyer, Blair Burnson, H. A. Harris, Jr., and by the operators.

Sewage Treatment Group

8:00 P.M. DISCUSSION OF OPERATORS' SPECIFIC PROBLEMS

Operators were requested to submit their particular difficulties and problems, in advance. These problems were discussed by a panel consisting of C. G. Hyde, E. A. Reinke, H. F. Gray, R. R. Ribal, Earl M. Kelly, W. T. Ingram, and by the operators.

Friday, June 24, 1938

Water Treatment Group

9:30 A.M. to 3:00 P.M.

The operators were taken to the San Pablo Filter Plant of the East Bay Municipal Utility District, where, under direction of Blair Burnson, Assistant Sanitary Engineer of the District they observed and recorded the operation of the plant, measuring and determining all chemical dosages, quantities filtered, wash water used, results obtained, routine laboratory controls, etc.

Sewage Treatment Group

9:30 A.M. to 4:00 P.M.

The operators were taken to the activated sludge sewage treatment plant in Golden Gate Park, San Francisco, where they observed and recorded the operation of the plant, determining and calculating sewage flow, air quantities, removal of solids, power requirements, results obtained, etc. The group was then taken to the new sewage treatment plant under construction at the west end of the Park, where the plant was described by engineers from the City Engineer's office. Harold F. Gray in charge.

A copy of the schedule of work required at the plant is attached to this report.

General Session

7:30 P.M. to 9:30 P.M.

Examinations on the material presented during the course were given to each group. A copy of the examination questions for the sewage operators' group is attached to this report.

At the conclusion of the examination, the operators were presented with Certificates of Attendance. A copy of the Certificate is attached to this report.

Sessions were held in the Life Sciences Building at the University of California, except for the day of plant practice, which was held at the plants stated in the foregoing schedule.

The underlying purpose of the short course was to give the operator an understanding of some of the more important principles underlying his practical work, and covering the "why" and the "how" of his job. Information was presented principally by means of demonstrations and discussions during the first two days, followed by the actual use of the information, in a plant in regular operation, on the third day. The short course was an intensive period of study, as thorough as the time limita-

tion would permit. The operators were diligent in attendance, applied themselves strictly to the business in hand, and were apparently greatly interested at all times.

The panel discussion held Thursday evening, June 23rd, was especially interesting, and animated and informative discussion was contributed by the operators as well as by the panel members.

Some of the questions put by the operators were as follows:

1. In selecting a pump for sewage works service, how can its sturdiness and freedom from operating troubles, as well as its efficiency and hydraulic characteristics, be determined in advance?

2. What measures can be taken to avoid complaints, largely from algae growths, where it is necessary to discharge a clear, stable effluent into a creek flowing through a park?

3. What is the best method of handling digester supernatant liquor to avoid odor nuisance?

4. How can a thick mat of undigested tomato skins on the top of a covered digester be removed?

5. What effect will distilling slops have on the operation of an Imhoff tank?

6. How can we prevent chunks of automobile casing rubber, probably from a re-tread plant, from clogging pumps?

7. How do you measure the chlorine demand of sewage?

8. Will flies breed in the supernatant liquor from digesters, and how can this be prevented?

9. What metals are most resistant to corrosion under sewage plant conditions?

10. What are the best methods of grease removal, and how difficult is grease and oil to handle?

11. How can clarifier sludge be thickened, before introduction into the digester, so as to improve digester performance?

12. How can excessive ground water infiltration into sewers be reduced before reaching the sewage treatment plant?

The following is the list of men who took the Sewage Treatment Course:

Marvin Anaya,
On Civil Service Eligible List for Position as Sanitary Engineering Designer,
City of San Francisco

James C. Clark,
Operator of Sewage Treatment Plant,
Huntington Beach

Joseph Corrao,
Supt. of Sewage Pumping Plants,
City of San Francisco

D. J. Herring,
Plumbing Inspector & Sewage Plant Operator,
City of Parlier

Ludwig Huebner,
Operator, Sewage Treatment Plant,
City of Palo Alto

H. H. Jeffrey,
Asst. Chemist, Division of Water,
City of Sacramento

F. W. Jones,
Supt., North Disposal Plant,
City of Stockton

Ira C. May,
Chief Operator (Sewage Division),
City of Sacramento

Reuben H. Owens,
Sanitary Engineering Designer,
Dept. of Public Works,
Bureau of Engineering,
City of San Francisco

J. W. Parr,
Pumping Plant Superintendent,
City of Manteca

J. P. Pope,
Mechanical Engineering Designer,
City of San Francisco.

A. B. Shearer,
Manager, Marin Sanitary Dist. No. 1,
San Anselmo

J. B. Welch,
City Marshall and Sewage Treatment Plant Operator, Ojai

Fred A. West,
Chief Operator, South Disposal Plant,
City of Stockton

Robert D. Woodward,
Chief Operator, Sewage Treatment Plant,
City of Laguna Beach

The following is a statement of receipts and expenditures on account of the School:

RECEIPTS

20 Water Works Operators Fees @ $3.00		$ 60.00
15 Sewage Works Operators Fees @ $3.00		45.00
		$105.00
Less fee ($3.00) refunded to W. H. Moulton, unable to attend on account of sickness in family		3.00
Net Fees Received		$102.00
(19 Water, 15 Sewage)		
Sale of 15 Booklets on "Sewage Plant Operation" @ 50c each		7.50
Net Cash Receipts		$109.50
Postage Stamps		
From California Section, A.W.W.A.		9.00
From California Sewage Works Assn.		7.50
Total Net Receipts		$126.00

EXPENSES

100 Postcards		$ 1.00
Express collect on 25 copies of "Water Supply and Treatment," furnished free by National Lime Association and distributed free to water treatment plant operators		
Cost of 15 copies of "Sewage Plant Operation" purchased from Municipal Sanitation		$ 7.15
Printing of Certificates of Attendance (50)		7.73
Extra Clerical Services		10.00
Geo. A. Webber—Refund of Expense, Palo Alto to Berkeley & ret.		5.50
Bridge tolls	1.00	
90 miles @ 5c	4.50	
Harold F. Gray		2.00
Bridge tolls to S.F., 6/16/38	1.00	
Bridge tolls to S.F., 6/24/38	1.00	
Miscellaneous Expense		1.26
Group photo for Western City	.43	
Examination books	.83	
Postage Stamps Used		16.50
Total Expense		$ 52.90

RECAPITULATION

Total Net Receipts	$126.00
Total Expense	52.90
Net Profit	$ 73.10
Deduct Postage Stamps Furnished	16.50
Net to be pro-rated to sponsoring Associations	$ 56.60

19/34 x $56.60	$31.60
pro-rated to Cal. Sec. A.W.W.A.	
15/34 x $56.60	$25.00
pro-rated to C.S.W.A.	
Check of Harold F. Gray sent to Secretary-Treasurer, California Sewage Works Association, for	
1. Pro-rata of profit	$25.00
2. Refund of postage	7.50
Total	$32.50
Check of Harold F. Gray sent to Secretary-Treasurer, California Section, American Water Works Assn.	
1. Pro-rata of profit	$31.60
2. Refund of postage	9.00
Total	$40.60
Total Refunded to sponsoring Associations by Harold F. Gray, Chairman, Committee on School for Operators:	
To Cal. Sec. A.W.W.A.	$40.60
To C.S.W.A.	32.50
Total	$73.10

Receipts for expense items are retained by the committee chairman, subject to examination by the Auditing Committee of the sponsoring bodies.

In addition to the foregoing expense, letterhead and envelopes were furnished by the two associations, and a considerable amount of clerical work, mimeographing, correspondence, furnishing of paper, stencils, large manila envelopes, postage, etc., was handled in the office of the committee chairman without charge.

Your Committee has reason to believe that the short course was entirely successful within the limitations necessarily imposed by available time and facilities.

We wish to express our thanks for and appreciation of the time and effort given to the short course by both the teaching staff and the members of the Advisory Committee, all of whom served without compensation for their services.

Respectfully submitted,

Committee on School for Operators,

J. F. BYXBEE
A. PERRY BANTA
HAROLD F. GRAY
Chairman

PUMPS FOR SEWAGE WORKS PRACTICE

By WILLIAM N. BEADLE, Vice President
BYRON JACKSON CO.

NOTE: The paper of Mr. Beadle included a group of photographs showing: (1) modern sewage plant pump installation, (2) drawings indicating general dimensions and design features of different types of pumps and (3) a large number of efficiency curves. It is impracticable to present all of this material and the original paper has been slightly modified in the following presentation. — Secretary

This paper is intended to be a brief review of the subject as a preliminary to a general discussion. An effort will be made to limit the paper to fundamental points on pumping practice for sewage, and analysis of various types of sewage pumps.

In general, it may be stated that much improvement has been made within the last few years in the design and construction of sewage pumps, permitting important economies to be realized. Not so long ago, it was felt that a non-clogging, dependable sewage pump necessarily could not have reasonably high hydraulic efficiency; but that efficiency must be sacrificed in favor of general dependableness, and continuity of operation.

Today sewage pumps are available with unusually high hydraulic efficiencies, and are remarkably free of mechanical troubles that in the past have caused shutdowns for repairs and clean-out jobs.

Hydraulic efficiencies vary with the size of sewage pumps, and will range from 70 to 75% for a 2½ inch pump up to 80% with a ten inch unit, the latter pumping 6000 g.p.m. at a head of 130 feet.

Generally, sewage pumps may be broadly classified as of the vertical and horizontal types. Of late years, important refinements of mechanical construction have been developed for both types. Some of these improvements will be discussed, and field photographs and sectional prints with this paper illustrate a few of the more interesting and modern installations.

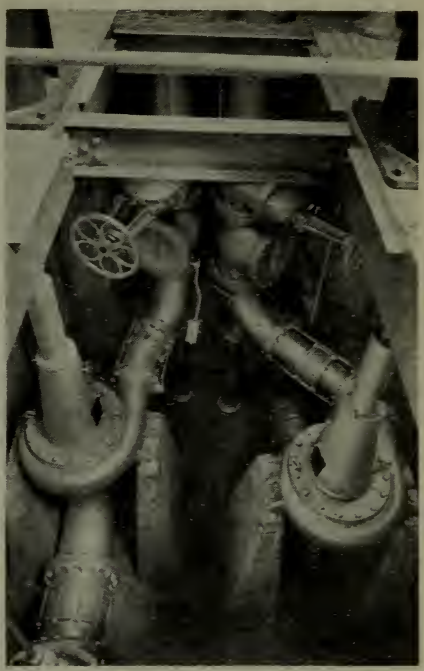
The City of Los Angeles Terminal Way Sewage Plant at Los Angeles Harbor is typical of a thoroughly modern installation using vertical pumps. The pumping pit structure, part of which is below sea level, is a circular, reinforced concrete well, with an inside diameter of 34 ft., and an inside depth of 24 ft. The portion of the cylinder below the motor room floor is divided into wet and dry wells, by means of an inner concentric cylinder of 13 ft. inside diameter. This inner cylinder is a dry well, where the vertical pumps are located.

The concentric cylinder arrangement reduces the amount of concrete and steel reinforcing to a minimum, both for the outer and inner walls,

because the cylinder is a shape which, under both internal and external pressure, requires the least amount of material for a given volume and therefore gives the largest amount of storage for sewage. Also during construction, the cylindrical shape of the pumping structure was an important aid in sinking it as a caisson in the presence of fine sand and water.

The wet wall is divided into two parts, and into each half there extends a suction pipe from a pump. This arrangement allows either half to be pumped dry and cleaned, while the other half is in operation.

Both pumps were purposely made the same rotation, so that one set of spare parts is sufficient, being suitable for either unit. The pump and motor are connected by means of a stainless steel shaft enclosed in a telescope column or tubing for lubrication protection and safety.



Terminal Island Pumping Pit

It is important to emphasize that Dayton couplings, with tension tie rods, were used to connect the pump with the large suction and discharge piping. This type of coupling is very advantageous in eliminating harmful stresses, tending to cause misalignment of the pump shaft, and facilitates installation or removal of such units.

The pumps are 10-in. vertical, centrifugal, single stage units, with two-port, non-clogging bronze impellers of higher than usual efficiency for this type of pump. The plant capacity is 4,275 g.p.m. at 60 ft. total dynamic head.

The surge, or "water hammer" from the force main is taken care of by a special design of surge tank. The entire plant is automatically operated, electric motors being started and stopped by means of floats.

An outstanding example of a modern installation of the horizontal type of sewage pump is that for the City of Honolulu. Four horizontal pumps were installed, each being an 8-in. two port, single suction, horizontally split case unit.

Particular points of interest in the design are (1) the especially large shaft supporting the one piece, two-port, overhung single suction bronze impeller, and (2) the combination split babbitt lined sleeve bearings for radial load and ball bearings for axial loads, which are a part of the heavy and substantial bearing structure.

Stainless steel renewable shaft sleeves protect the shaft from the impeller hub back through the stuffing box, which is of liberal depth and provides for the conventional clear water seal. Such sealing water is furnished from a source carefully guarded against any contamination.

Renewable bronze wearing rings protect the suction eye of the impeller and the pump housing adjacent thereto.

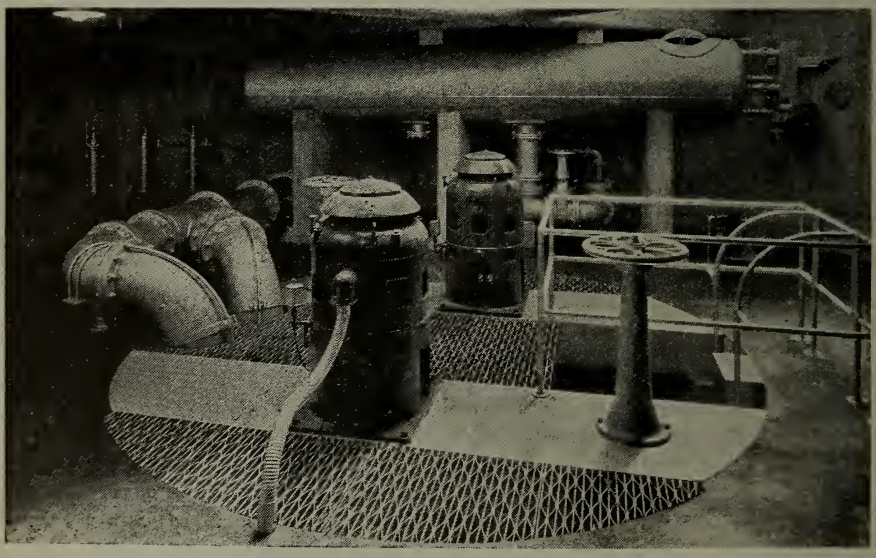
While the pump housing and bearings include the rather unusual mechanical construction of being split in the horizontal plane, for convenience in removing the complete rotating element, a hand hole of liberal proportions is located immediately adjacent to the eye of the impeller, permitting the removal of any over-size obstruction which might reach this point.

A major item of interest to all users of larger sewage pumps is the arrangement of suction and discharge piping connections in the bottom half of the pump housing only, so that these piping connections are not disturbed when the pump is dismantled for inspection of the rotating element, or any replacements.

Each of these units was required to deliver 2,100 g.p.m. of raw sewage at 75 ft., at 1,165 r.p.m. Under actual test, pumps met the head capacity requirements at an efficiency of 79½ per cent; with each unit capable of passing a 3¾" sphere without clogging.

A variation in the vertical type of sewage pump is in service on the Orange County Cities (California) Joint Ocean Outfall Sewer. Three units are included, 8,500 g.p.m. at 10 ft.: 6,250 g.p.m. at 10 ft.; and 11,000 g.p.m. at 10 ft. These pumps include the propeller type of runner. One unit is gear driven by a gasoline engine for emergency.

The arrangement of the pumping plant and the extremely simple



Terminal Island Pumping Plant

piping arrangement has proved very satisfactory for this type of station.

A portable sewage unit, usually gasoline engine driven, is frequently required for emergencies and general utility work. The mechanical details of such a pump itself are substantially standard, with the two-port, non-clogging type of impeller.

A new design of runner is now available for a vertical or horizontal type of sewage pump for unusually large volumes. It is very difficult to clearly describe this runner, because of its unique arrangement. Briefly, the runner is of a strictly non-clogging design, having four ports, two ports on either side, and a double suction. This permits of the use of suitable bearings on both sides of the runner, and necessitates the use of special shaft sleeves, which do not rotate with the shaft, thus guarding against any "winding up" of strings, rags, etc., around the shaft.

It may be said here that the practice of some years ago of installing sewage pumps in wet wells is meeting with less favor. Installation of both vertical and horizontal pumps in dry sumps, adjacent to the wet well is now the more common practice.

A typical, modern horizontal sewage pump, usually includes renewable case wearing ring to maintain efficiency, and up to a certain size is generally equipped with ball bearings. Such pumps should also include renewable shaft sleeves, which may be bronze, monel or stainless steel. Clear water sealing of the stuffing box is very advantageous.

In the larger horizontal sewage pumps, the design usually includes heavy ball bearings, and renewable rings for both pump case and runner. Convenient location of suction handhole is important.

The City of Honolulu installation includes horizontally split pump case, with suction and discharge nozzles in the lower half to permit inspection, or replacement of complete rotating element within a minimum of time. The runner is of the two-port non-clogging type. The bearing is of unusually heavy construction, including split babbitt lined sleeve bearings for radial, and ball bearings for axial loads.

Improvements will be discussed covering bell-mouthed suction entrances, insuring greater entrance area, and also preventing the admission of solids or spheres which will not pass through the pump runner. An installation of this type has recently been made in Hollywood, California, including four pumps, each pair of two pumps operating in series to meet the requirements of an unusually high discharge head. We do not know of any "two stage" or multiple stage, non-clogging sewage pumps that have been successful, for reasons that will be discussed.

Performance curves are attached to this paper for discussion, covering units from 2½ in. to 10 in., the latter non-clogging runner passing five inch spheres, and attaining eighty per cent pump efficiency. It is of special interest to realize that runners of various diameters for each size of pump can be furnished, giving a wide range of volumes and heads.

In closing, may I emphasize that pump manufacturers welcome constructive criticism from the field, and it is urged that sanitary engineers submit their questions and criticisms to the pump manufacturers so that we may push on to further progress in this important field.

ITEMS TO BE CONSIDERED IN SELECTING PUMPS

By J. CORRAO

The purpose of this paper is to present certain suggestions in selecting pumps for sewage which come under the classification of horizontal and vertical centrifugal types and based on operating experiences in the plants of the City of San Francisco.

Pumps for municipalities are usually selected by competitive bidding. In those cases it is necessary to write specifications so that a number of manufacturers can bid. Objections are raised by the manufacturers if the specifications include special requirements that do not conform to their standards. Best results can be obtained by writing specifications as rigid as practical to permit only manufacturers of high standing to bid and to include those features which are considered essential and that do not involve too much deviation from standard practice. In cases where pumps can be selected without competitive bidding, consideration should be given to operation and maintenance costs, first cost, power requirements, reliability of manufacturer and facilities for service and repairs.

One of the most troublesome problems confronting the operator of sewage works in regard to pumping machinery is clogging. The nature of the material being pumped is such that in spite of modern design to overcome this trouble, it will be found in practice that the theories involved are far from perfect. Binding of rags around the shafts and impeller together with sticks, rocks and many other obstacles finding their way into the pump and restricting passages, are the causes of inefficient operation and shut downs which in some cases are costly. For these reasons too much care cannot be exercised in investigating this feature of a pump.

When horizontal sewage pumps are to be used, it will be found that the split case type has a great advantage over the solid case type. In the former there is a flanged joint between the upper and lower sections which facilitates removal of the top section thus permitting access to the impeller without the necessity of removing the complete impeller and shaft as is the case in solid case units. Removing the complete impeller in the latter case generally involves the removal of the bearing pedestal and disconnecting of the flexible coupling and also shifting of the prime mover on its bed plate, all of which takes considerable time and is costly.

The casing of a pump should be made of close grained cast iron and should be provided with an access opening as large as possible located on the discharge side of the volute. The plate should be bolted to the casing. This opening facilitates removing rags and other obstacles which become wound around the shaft or impeller. Tapped holes on bosses should be avoided as they are of very little assistance in removing particles of any size and permit access to only a small area. How-

*Superintendent of Pumping Plants, City of San Francisco.

ever, a tapped hole should be provided at the bottom of the casing for drainage purposes.

Because of certain inherent difficulties, manufacturers do not make vertical pumps in the split case type excepting in very large sizes. When selecting a unit of this type, a hand hole access plate should be provided on the volute at the discharge side.

Horizontal type pumps should have a tapered suction which is provided with a hand hole plate on the upper side because quite often obstacles become lodged in the suction and unless they are removed, the opening soon becomes considerably restricted and causes inefficient operation of the pumps. Suction heads should be tapered to prevent high spots and consequent accumulation of air. With vertical type units, a hand hole plate should be provided on the outer surface of the suction elbow.

While on the subject of hand hole plates, it might be well to mention that the gate valves located on the suction and discharge and also the check valve on the discharge of sewage pumps when 6 in. and over, should have access plates. On gate valves this plate should be located on the side of the valve at the seat and with the check valve the handhole plate should be located at the top and in the cover plate. These improvements will prove well worth their additional expense.

The question of design of impellers is one which has caused considerable argument and discussion. Experience of operators in various sections differ on this subject, but our experiences have proven that two bladed closed impellers have given better results. There is more chance of rags winding around the impeller in the case of the open type. Bronze impellers have been used exclusively to date in our plants, but in one of the plants now being constructed, a pump is being installed with a cast iron impeller. The reason for this is that it was considered desirable to compare results with an identical pump having a bronze impeller. These units will be subject to the same operating conditions but will not be in operation for several months and consequently no recommendation can be offered at this time.

The passages through the impeller and pump should be large with no corners or sharp edges to cause clogging. For maximum efficiency narrow clearances are unavoidable at wearing parts and at joints between impeller and casing, and therefore these parts should be designed to eliminate accumulation of solids. Closed impellers with end suction inlet construction afford the least obstruction to flow and give added freedom from clogging. With this construction it is advisable to use renewable bronze wearing rings on the impeller and tapered suction head.

A water seal should be provided to prevent grit or sediment from becoming lodged between the wearing rings which are only separated by a small clearance. Careful consideration should be given to the actual clear openings of passages through the impeller. The fact that the pump is classified at a given size of discharge does not necessarily mean that it will pass a sphere of that same size. In some cases the reduction in size amounts to 50%, consequently the size of sphere that

is desired for a pump to pass should be clearly specified. When an elbow is installed in the suction line and turns at right angles to the center line of the pump, it will cause unequal flow to each side of the impeller especially those of the open type. This tends to reduce capacity and cause excessive thrust. It is advisable to avoid this type of arrangement if possible.

When considering vertical type pumps, an item often overlooked is the matter of framework. Where there is a long connecting shaft between the motor and pump, this item should be given careful consideration. In cases where competition is keen some manufacturers might cut the size of the channels and flat steel bracing to a minimum in order to save in construction and shipping costs. In such cases it will be found that the bearings located in the framework will be subject to strains and cause misalignment with consequent excessive wear on the bearings. Also, if the structure is flimsy, considerable vibration will be the result which will further add to the above mentioned difficulties. Where the interconnecting shafting is too light, whipping of the shaft will cause a permanent set to occur and eventually replacement of the shaft will be necessary.

In vertical type units and where there is any possibility for a choice, it would be advisable to select a coupling arrangement with a rigid coupling connection at the pump end and the flexible coupling connection at the prime mover which in most cases is an electric motor. This system makes it easier to realign the shaft when repairs are made.

Horizontal pumps of large capacity are generally provided with cast iron bed plates. Provision should be made for grouting the plate to the foundation. A hole about 6 in. in diameter is generally provided in the top of the plate. Grout should be poured through this hole after the plate is set on the concrete foundation and care should be taken that the grout flows freely and is forced completely throughout the space under the plate. The reason for this precaution is that cast iron generally warps with age, and unless held properly, strains may be set up which will cause the bed plate to crack. A good grade of cast iron properly treated is essential for best results.

The item of bearings in pumps is one which requires continual observation. Consequently the proper selection and arrangement of bearings is of great importance in selecting a pump. Horizontal type units generally have two bearings of the ball bearing type, with one bearing placed at each end of the bearing pedestal. The impeller is usually overhung and heavy loads encountered suddenly place a severe duty on the bearings. Only bearings manufactured by firms of the highest reputation should be used because the most minute nick or defect in the balls or raceway will very shortly cause the bearings to be noisy and result in premature replacements. One defective ball in the race soon damages the raceway and causes the other balls to become defective.

Sleeve bearings are not very commonly used in sewage pumps of modern design. The fact that there is a large bearing surface between shaft and bearing sleeve causes considerable increase of friction with

the consequent increase of power required. When the unit is started from rest, the power required is considerably in excess of that required when ball bearings are used. There is one advantage in the sleeve bearing and that is the increased bearing surface permits less vibration in the shaft. This is an item that will always be found in cases where a horizontal pump with overhung impeller is being used. The vibration is the cause for a considerable amount of packing trouble because most packings lose their resilience shortly after they are installed and consequently the vibrations cause voids resulting in leakage at the gland.

Conforming with the design of split case pumps, bearing pedestals are also designed on this principal. The flanged joint between the upper and lower section permits removal of the top part and the bearings may be readily inspected. The two sections are bolted together at the flange. The pedestal housing should have ample provision for flushing the entire housing.

The question of using grease or oil in bearings is largely a matter of opinion. Experience in the plants of San Francisco indicate that grease is more desirable because it is more easily held within confinements and does not leak through the retaining seals as readily as oil. There is more waste incurred when using oil because the oil leaking through the seals either drips down the casing or is thrown from the revolving shaft. Also, oil collects dirt readily causing increased maintenance work. Oil is most generally used in sleeve bearings because it works its way over the area of the bearing giving satisfactory results. It is difficult to keep grease in this type of bearing.

In many pumps the method of holding the oil or grease within the confines of the bearing, whether ball bearing or sleeve bearing be used, can be improved. This problem is usually handled by an oil seal ring placed in the bearing housing and consists of an annular ring which houses a leather ring that fits close to the shaft for the purpose of obstructing the flow along the shaft. The circular ring is generally made of one piece of metal which causes considerable difficulty upon removal, especially when the ring is situated on the coupling side of the unit because in this case the half of the coupling located on the shaft must be removed in order to slide the new ring on. Removing the coupling on a horizontal pump connected to a motor requires that the motor be removed from its base and shifted, except where the pump is of the split case type. In a vertical pump the entire connecting shaft will have to be removed to accomplish the same result. When one considers that the cost of the seal ring is practically an insignificant item and that to remove it involves considerable labor and loss of time, it will be readily realized that some improvement should be made in this particular feature of design. Some of the leading packing manufacturers are now making a unit known as the "Split Klosure" and also "Chevron Split Packing."

In writing a specification for a pump to be purchased, this matter should be carefully considered because considerable maintenance expense can be avoided by specifying one of these types which permit re-

moval and replacement without disconnecting the pump assembly. In the case of vertical pumps, the bearing pillow boxes can be altered at nominal expense to have a gland attached to the casing which would accommodate the types of oil and grease seals stated above. Considerable expense has been saved at two of the plants in San Francisco by brazing glands to the pillow blocks. The glands are machined to accommodate "Chevron Split Packing" as manufactured by Garlock Packing Company. Grease is used in the boxes and the results have been satisfactory.

Scoring shaft sleeves at the packing gland due to abrasive action of packing which has absorbed grit from the sewage is a problem that the majority of manufacturers are confronted with. Within the last few years this has been given considerable attention. The rapid strides recently made in the field of alloys have made it possible to obtain sleeves with corrosive and abrasive resisting qualities which eliminate a great deal of the difficulty formerly encountered with the old type sleeves. Monel metal, stainless steels and nickel alloys having Brinell hardness running from 275 to 600 are now available and should be demanded in specifications for pumps. Some of the manufacturers are now using these materials as standard equipment for sewage pumps.

The question of shaft size is important in that it results in considerable trouble if not properly selected. Here again with the advance of modern alloys considerably better wearing qualities are to be found; also, the tensile strength has been greatly increased. Competition sometimes forces manufacturers to furnish shafts just large enough to adequately carry the load, but the matter of vibration is not adequately taken care of. Shafts should be specified oversize in order to avoid difficulties due to vibration.

Flexible couplings in order to be truly flexible must be free from binding or freezing effects. There should be freedom of motion axially. The coupling should be capable of compensating for a nominal amount of misalignment. A common type of flexible coupling now used by many manufacturers consists essentially of two cylindrical discs with hubs and are set at the ends of the shafts by keyway and set screws. The discs are coupled together with filister head bolts which should be made of stainless steel having shallow heads and hexagon nuts. The bolts are housed in bronze sleeves which in turn are housed in high grade rubber and which fit into the recesses provided in the discs. This type has proven successful in the plants of San Francisco.

When this type of coupling is used, care must be taken to remove the bolts at intervals not to exceed six months and coat them with vaseline to prevent binding. This item should not be neglected in maintenance routine because the hydrogen sulfide gas found around sewage works causes a crustation formed by a limited amount of corrosion of the bolts and bushings and causes them to bind with the result that the coupling becomes rigid and generally causes bearing trouble due to excessive thrust which is caused by lack of freedom for floating of the shafts. Other types of couplings are available which are satisfactory for small units. They are based on having two discs with protruding pins

between which leather discs are placed or in some cases a leather strip formed into a ring is woven around the pins. These joints have a tendency to break more readily because, unless the leather is properly dressed and maintained, rotting will set in and the leather will break.

Recommendations regarding packing have not been given in this article because tests are being conducted on several classes of packing which are being subjected to identical operating conditions and since these tests have not been conductd over a sufficient length of time, it is considered more advisable that the results should not be discussed at this time.

The question of whether a vertical or a horizontal pump should be selected for a particular job depends entirely upon the problem involved and the existing conditions. Certain general statements can be made which might aid in the proper selection. In considering the hazard of flooding, vertical pumps arranged for self priming and located at the bottom of the dry well and driven by a prime mover placed above the pump a sufficient distance to be assessible and in a dry area, have a distinct advantage over horizontal pumps located at the bottom of the dry well. In some cases this advantage warrants the increase in cost of the vertical unit. The building space requirements are generally less for the vertical unit when analyzed may more than offset the increase in cost.

Automatic vacuum priming has been perfected sufficiently to warrant using horizontal pumps of small sizes when it is not possible to construct deep dry wells. However, whenever possible, horizontal pumps should be arranged with positive suctions. Horizontal units can more easily be repaired and serviced than the vertical units. Stations equipped with horizontal pumps are more pleasing in appearance. Where it is possible to have operators continually present, horizontal pumps are usually indicated, but if the station is to be unattended, it will be advisable to install vertical pumps.

Where special problems are encountered such as sand, grease, etc., a standard pump does not always meet the requirements. In such cases it is better to provide special materials for impellers, sleeves, etc., and pay the additional cost rather than be confronted with continuous maintenance trouble.

PACKING FOR PUMPS

By BARD LIVINGSTONE*

All pumps, regardless of the make or the conditions under which they operate are equipped with packing boxes. It is the function of the packing which is placed in these boxes to prevent air, water, oil or other liquids from escaping from the pump by accompanying the rotating shaft through the box. This has been accomplished with oiled hemp, rubber and other fabricated packings.

During the past ten years there have been developed plastic packings that have come into general use. Not only has a general purpose plastic

*Superintendent, Water and Sewage Disposal Depts., San Bernardino.

packing been developed but packings can be obtained to suit any pumping requirement such as hot or cold water, saturated steam, acids, alkaline and caustic liquids, hot oils and many other specific purposes. This fact should be kept in mind and a packing suited to the pumping requirements used.

The important features in the selection of stuffing box packings besides having a material suited to the pumping requirements is that it will not cause wear of moving rods or shafts, will operate with a minimum of friction and will prevent leakage for a considerable length of time, as well as being easy to install. These are the advantages that will be obtained by using a good grade of either metallic or fabricated packings. Metallic packings usually consist of combinations of an anti-friction metal, such as lead, aluminum foil or other soft metals with an oil and mineral lubricant such as graphite. This lubricant will form a film or coating on the shaft or shaft sleeves, as the case may be, and between the shaft and the packing. This will reduce the friction and resulting wear to the metal and packing, allowing the stuffing box to run cool, which incidentally saves power.

There are many different types of metallic packing and it is made with or without a fiberous core. All manufacturers endeavor to construct a material which will conform readily and evenly to the contour of the stuffing box and shaft and be plastic and resilient so that the pressure that is exerted by the packing gland will be evenly distributed to the whole mass. One type of packing on the market uses a lubricant called Meta-film which coats over the shaft sleeve and gives the rotating parts a lustrous polish, filling pits and scores which are not too deep, thus helping reduce friction.

When fabricated packings are used they must be lubricated with some type of graphite grease. This can best be accomplished by having an Alemite connection on the lantern rings so that occasionally soft grease can be forced in to form an additional lubricant for the packing, and keep the packing soft and pliable.

Regardless of the type of packing used, the most important feature is that the packing be installed properly. The packing rings must be carefully fitted to the shaft with the ends cut squarely to fit exactly as each ring is fitted around the shaft. If the packing is properly cut on a bevel, it will make a very satisfactory job although we have found that by cutting the ends at right angles we have obtained the best results. In inserting the packing in the stuffing box only one or two rings of packing should be inserted at a time, care being taken that the joint of each ring is in a different position on the shaft to prevent leakage in the joints and through the packing. The faced ends of each ring should come squarely together when the ring is tight around the shaft. As the packing is inserted it should be thoroughly compressed into the bottom of the box by means of followers and thoroughly pressed into the glands before subsequent rings are added. It is advisable to rotate the shaft one-quarter turn as each application of packing is inserted so that adhesion of the packing to the shaft is broken. This procedure will permit the pump to start more easily when placed in operation.

It is very important that the position of the lantern ring should be slightly forward from the inlet circulating pipe. This will permit the lantern ring to continue to function without being pushed past the opening when the packing gland has been subsequently tightened. After packing, the gland must not be drawn up too tightly. The best adjustment is indicated by a slight leakage of liquid from the stuffing boxes. Excessive pressure on the packing will cause scoring of the shaft protecting sleeves and rapid deterioration of the packing itself. If the nuts are left finger tight it is usually sufficient.

To obtain the most satisfactory operation of any type of packing, it is of course absolutely necessary that the shaft run perfectly true and without any vibration. If either the shaft or the shaft sleeves are slightly out of round or badly pitted no type of packing will work entirely satisfactorily. Every effort should first be made to insure the smooth operation of the shaft sleeve to be packed. In case these are out of round they should be accurately ground to get them perfectly cylindrical before the pump is put in use. If this is not possible the best result can be obtained by using the softer type of packing with resilient cores which will hold better and conform to the irregularities more satisfactorily than solid metallic packing. However, on a shaft that is whipping badly an ordinary cotton type of packing will give as good service as any other type especially if the shaft sleeves are scored. When this condition exists if a harder metallic type of packing is used it will prove quite satisfactory when it is first installed. However, when it becomes necessary to further compress the packing by tightening the glands, the packing will be pinched against the scores causing the sleeves to thrust to one side or the other, making the gland run excessively hot. When this happens the packing must then be removed and re-packed with a follower rather than just tightening the gland nuts.

On any pump that is to operate under suction lift, both stuffing boxes should be liquid sealed. The ¼-in. tapped openings over the packing are to be utilized for this purpose. Each opening should be piped through a valve to an external source of clear liquid free from sand or grit. In this way there will always be a small amount of clean cold water working both ways along the shaft sleeves which will prevent any abrasive liquids or corrosive fluids from working into the gland and injuring the packing. With the packing properly adjusted, fifteen to twenty pounds pressure greater than the pressure developed in the inside of the packing gland, is sufficient for effective sealing. This is the reason for the importance of properly locating the metal cage or lantern rings when packing the pump so as to permit the free circulation of the water. The liquid seal is not required for operation under positive suction pressure.

In re-packing a pump it is always advisable to remove all of the packing using hooks or corkscrews inserted at points diametrically opposite to each other for best results. There are several types of packing hooks that can be used. One type that has proven satisfactory is a hook that is securely fastened to a flexible steel cable and furnished

with a suitable handle so that these hooks can be used in very close glands where there is not sufficient room to use the ordinary type of hook. Care must be used in handling any type of hook as they are usually made of tempered tool steel and will score the softer bronze sleeves if not used properly. After the packing has been removed, if it is a good type of material, it can be cleaned, scraped and re-packed into the gland adding new packing when necessary. The gland should be tightened uniformly on each side so as to compress the packing evenly and to insure against binding the shaft sleeve. The final adjustment to be made after the pump has been in operation a few minutes.

Too much emphasis can not be made on the importance of the proper selection of the packing used to suit the requirements of the work. For reciprocating rods working against steam or air pressure, usually the high pressure types of packings are selected. These packings have a rubber impregnation which is acted upon by the heat encountered to vulcanize it into durable form, as it is on account of the rubber compound that the high pressure packings are limited to use on reciprocating rods and are not generally suitable for use on high speed rotary work. For extremely high speeds ranging from 1750 R.P.M. to 6000 R.P.M. great care must be used in selecting and applying packings. On slower speeds the selection of packings is a much easier matter, but it may be said, that any packing which is suitable for a high speed condition would be ideal for a low speed condition.

The flexible metallic packings are used extensively, and if applied to steel, cast iron, monel metal, or hard rods, plungers or shafts other than brass or bronze, will often give long periods of satisfactory service, provided they are installed on apparatus running in true alignment, and on parts free from wear, scores, or shoulders. The flexible metallic packings should not be installed on high speed brass or soft bronze shafts, rods or plungers as the lead element is apt to amalgamate with the brass or bronze and produce rapid deterioration of the packing, or scoring or cutting of the shaft, rod or plunger surface. This does not happen on steel, cast iron, or other hard metals.

Because of the large variety of packings on the market which are suited for practically all packing requirements, it is often very advisable to consult with a representative of a reputable manufacturing company. These firms maintain a staff of competent, specially trained men of long experience in the packing field. They will gladly assist in any possible manner in matters pertaining to packing problems.

SEWAGE PUMPS

DISCUSSION

By H. K. PALMER

Mr. Beadle mentioned the size of solids passed by one of the pumps, but he did not emphasize that the efficiency of a sewage pump is dependent upon this size. For best efficiency the velocity of the water through the impeller should be constant, or should increase somewhat toward the outlet. In the old style sewage pump in which an 8-in. pump was supposed to pass a 6-in. ball, the area of the entrance to the impeller would be 50 sq. in. and each of the outlets 36 sq. in. or 72 sq. in. in all. Water would pass through this impeller in about 1/20 sec., which is entirely too short a time for its velocity to be reduced 33%. Either the passages would not be entirely filled with water, resulting in cavitation, or eddies would be set up, resulting in loss of efficiency. Experience with pumps that have been in service long enough to be practically worn out shows that the greatest wear occurs where there are the most eddies. Therefore increasing the efficiency not only saves power bills but lengthens the life of the pump.

By reducing the water passages of the impeller to pass a ball whose diameter is about 5/8 the diameter of the entrance a much better efficiency is obtained. At the present time the better companies prefer impellers with the smaller size outlets but they must be prepared to supply the larger size to meet the specifications of some engineers. If a reasonably spaced bar screen is used ahead of the pump this smaller size causes no inconveniences. The Los Angeles County Sanitation Districts have had good success using these smaller size impellers on pumps as small as four inch.

The use of sewage pumps as small as 3 in. is questionable but there have been a good many installations in which they have given satisfaction. For such a size it would be better to sacrifice efficiency and call for the pump to pass a 2¼-in. ball. For sludge pumps, which operate fewer hours per day than sewage pumps, 4 in. is about as small as it seems advisable to use, because of clogging, and a 4-in. pump for this purpose should pass a 3-in. solid, whereas 2½ in. would be the proper size for sewage. One pump manufacturer recommends nothing smaller than 6 in. for sludge, but this involves much larger pipe, and if the pipe is long it might require an excessive time of transit for any sludge particle. The use of a 6-in. sludge pump would depend upon the amount of sludge to be pumped and the length of the pipe.

For handling large quantities of water at low head the propeller type pump gives the best efficiency. In spite of claims that propeller pumps have been used successfully for raw sewage their use is questionable because it is necessary to place vanes just above the propeller and these vanes are apt to collect rags. There is another type which is a mixture between the propeller and centrifugal pumps, suitable for heads a little greater than the propeller pump and much less than the heads for the centrifugal. In this case there is a 3- or 4-bladed impeller similar to the runner of a turbine which throws the water to the side by centrifugal force, as in a certifugal pump, and no vanes are required. This type

has different names with different manufacturers, Worthington using the name "Mixflo" and Fairbanks-Morse the name "Angle-flow." After considerable investigation and upon good recommendation the Los Angeles County Sanitation Districts purchased two from the Worthington Co. to handle 10,000 g.p.m. at 8.5-ft. head. They have 30-in. suctions, 24-in. discharge and pass 3-in. solids. After running continuously for six weeks it was found that a few rags had collected on one of the runners, which floated off when the pump was stopped. These pumps are giving very good satisfaction and run for a month or more without stopping or collecting enough rags to cause a perceptible diminution in flow.

Bar screens are very essential and require less work to keep clean than clogged pumps. They should be made much wider than the incoming pipe, and it is well to have the bottom of the screen below the invert of the pipe. This permits the collection of a large amount of debris without actual clogging of the pipe. The plant should be so built that the bar screen is easily accessible so the operator can clean it once a day. The Los Angeles County Sanitation Districts have one station which pumps about 20,000 g.p.d. which is visited by the operator about three times a week, and no serious trouble has yet been caused by the screen clogging. These screens are usually made with 1 to 1½-in. clear openings, and the tines of the rake used for cleaning should have the same spacing as the bars. Cross bars should be so placed as not to interfere with the use of the rake.

Even when the pump is under a positive head at all times there is a tendency for the sewage to give off gases which form a gas pocket under the check valve, and if enough gas collects may fill the volute and impeller, which would prevent the pump operating when the current is turned on. This happens only when the spare pump has not been used for some time, but might happen just when the pump was needed the most. This can be avoided by providing a return pipe from the top of the casing of the pump to the wet well, but the constant flow of water through this pipe while the pump is running not only causes a waste of power but is apt to carry rags which may clog the pipe. A better method is to provide an air valve which will permit air to flow out slowly as the water rises in the pump, if it is above low water elevation, and will allow air to flow back into the pump when it stops, but will blow shut with a sudden rush of air when the pump starts or when the water rises in the pipe. This valve should be placed higher than the water surface in the wet well to insure its opening when the pump stops. It also permits water to flow backwards through the pump when it stops, thus backwashing it and removing any rags that may have caught on the runner.

Mr. Beadle mentioned one plant in which Dayton couplings were used to relieve the pump casing of all strain. This is an excellent idea and can be used very easily on the suction side, but on the discharge side it is necessary to provide bolts to keep the pipe from blowing apart. Victaulic couplings have been found to be a very good substitute to provide flexibility and the extra bolts are not required on the discharge

side. It would be a help if pump manufacturers could omit the suction and discharges flanges and substitute ends suitable for Dayton, victaulic or other flexible couplings. At present it is necessary to insert one or two special nipples with the extra flanges to attain this flexibility. It would insure all piping being separated from the pump by a flexible joint, with an assured freedom from strain.

With the exception of the double suction pump described by Mr. Beadle all 2-port sewage pumps have over-hung impellers. To avoid excessive pressure on the bearings the distance between bearings should be at least as great as the over-hang, and preferably more. To meet competition some makers try to lower the cost by decreasing this distance, but it is accomplished at the cost of heavier bearings or increased wear.

Floor area in a dry pit is often at a premium, especially where horizontal pumps are used, and since the space between the bearings is useless why not increase it enough to place the motor there, as used to be done with the pulley on belt driven pumps? Electric companies now sell synchronous motors without shaft and bearings, the rotor being mounted on the extended shaft of the machine and the stator being attached to the frame of the same machine. Induction motor parts could be supplied in the same way if a demand were created. This principle is applied now in small water pumps where the impeller is mounted on the extended shaft of the motor, the motor supplying the bearings. Manufacturers claim that the motor shaft and bearings are too light to withstand the strains in a sewage pump, so the suggestion is made that the pump manufacturers supply these and let the electric manufacturers supply the electrical parts.

REMODELING OF OLD SEWAGE TREATMENT PLANTS TO INCREASE EFFICIENCY

By J. A. HARMON*

The artificial methods of application of the natural forces of sewage purification are ever changing. Sometimes it even seems that the science of the art is in a state of flux. Despite the fact that much has been done during recent years to add to our scientific understanding of the phenomena involved in the purification processes, probably progress can be summed up by saying that the most outstanding attainments have been in the application of older basic scientific information in a more efficient manner by the use of mechanical equipment. In fact, new equipment and new arrangements of progresses are being brought forward so rapidly that it is not an easy matter even to keep a speaking knowledge of the innovations in this field.

This paper reviews the older treatment processes and devices and suggests a few ways in which present knowledge and available equipment may be adapted to older plants so as to improve loadings, efficiency or facility of operation.

The older plants not only find themselves outmoded by newer devices and refinements, but even their inherent capacities, which suffered by the use of bases of design since found to be too low, have in addition suffered by the overloading that ten, fifteen or twenty years population growth has brought.

There are in California at least 67 septic tanks, 80 Imhoff tanks and 42 trickling filters, not to mention other miscellaneous treatment units that for reasons stated above should be benefited by the newer practices in sewage treatment. The overloading that creeps upon sewage plants as they grow old comes on insidiously as does age itself and every so often something happens to make us realize the fact.

Of course one cannot make something out of nothing. Nevertheless an engineering study may sometimes indicate that it is good economy to remodel and modernize existing units. A thorough engineering study should by all means be made the basis of the decision on what to do. In some cases the old works simply cannot be salvaged or the original site may have become so untenable that adherence to it, even with modernized works, is poor judgment. On the other hand, modernizing the works may make a poor site tenable and so prolong the value of the investment. Each case must obviously be considered on its merits. As a rule, more errors are made by trying to make a go of an old existing site and catering to the popular notion to save the old works in the new, than in facing the situation squarely and moving onto a more suitable location and putting in works more exactly suited to the local needs.

Only rarely nowadays is a septic tank logical in new plans. The older tanks are generally wrong in principal and in performance. Yet among the easy transformations of old plants to adapt new ideas, is the conversion of septic tanks to separate digestion of sludge and simple addi-

*Junior Sanitary Engineer, California State Department of Public Health.

tion of a clarifier with mechanical sludge handling equipment; or as at Tulare, equip the septic tank with mechanical equipment to make it into a clarifier and add a digester. As a rule, septic tanks were given large volumetric capacity and that is why they can often be utilized in a modern plant.

To mention a few more instances, changes of this kind have also been made at Modesto, at San Juan Capistrano, and at Turlock where the old Trent aerators converted to septic tanks years ago, are now being changed to digestion units in a bio-filter disposal plant. The Yountville and Sonoma State Home septic tanks were once remodeled into Imhoff tanks. At the present time new plants are being designed at these places and the old plants are to be finally abandoned.

Imhoff tank design started out 25 years ago on the basis of allowing approximately .75 cu. ft. of sludge space per person. Nowadays 3.0 cu. ft. is not uncommon. The overloading of Imhoff tanks is therefore apparent. Yet it is often possible to change an Imhoff tank to a separate sludge disposal plant by converting the Imhoff tank to a digester unit and adding a separate clarifier unit. This change was made by Mr. C. C. Kennedy at Stockton and by Mr. Frank Currie at El Monte. Mr. Currie, who will discuss this paper, has plans for using the Imhoff tanks at Visalia and Delano in his new plants at these cities. If the sludge digestion compartment of the Imhoff tank reaches its capacity ahead of the settling compartment, it is sometimes possible to add a supplementary separate sludge digester or sludge lagoon as has been done at Pomona. In effect such changes may grace the name multi-state digestion, one of the very latest of the innovations in sewage treatment.

Heating sludge is one of the present day advances in the art. However, Imhoff tanks can utilize this feature only by providing them with slot-closing mechanisms to prevent upward thermal currents. This is not a simple matter in the case of old tanks but such a mechanism has been used in a new Imhoff tank at Oxnard. Closing in the gas vent areas and collecting the gas is another page that may be drawn from separate sludge digestion and turned to benefit with new Imhoff tanks and conceivably with older ones. Several new Imhoff tanks are so equipped. Where good scum removal from flowing-through chambers is desirable, skimmer devices can be adapted to Imhoff tanks, especially air jets or water jets, combined with a scum gutter.

At Whittier, where as a result of a long outfall, the sewage reached the Imhoff tanks in foul condition with the dissolved oxygen depleted, a pre-aerator was installed to freshen the sewage for its travel through the tank so that it did not reach the sprinkling filter nozzles in a septic, odorous condition. Still another modern device applicable to Imhoff tanks, is the Scott Darcy Process for odor control and for improved sedimentation. At the Los Angeles County Sanitation District's activated sludge plant, chlorination of the sewage for control of septic conditions in the collecting system resulted in increased efficiency in the activated sludge process.

The old fixed nozzle distributor for trickling filters is seldom seen in new installations, yet there are 42 plants of this type in California and

many of them are now overloaded. Offhand, I would say that by and large filters using them are perhaps only 60 to 75% effective, judged by the large number of nozzles that are out of use on our inspections.

The modern filters use rotary distributors that not only clog less easily but operate on several feet less head and the reduction in fall of the spray does not aerate out the odors quite so badly.

The revolving type distributors are adaptable to older filters with comparative ease. Furthermore, additional capacity can be had with almost no disturbance of an existing unit by simply adding new outside walls, flooring, drains and stone outside the old filter. By reason of the 3 feet or so less head for spray purposes, rotary distributors also permit increasing the depth of the old trickling filter by several feet and thus gain an outright increase in capacity by this one step, of perhaps fully 30%. I know of no such change having been made in trickling filters but it appears to me the idea is perfectly feasible.

A review of the practice in California appears to indicate that because of the desire to locate the disposal sites to get better isolation, the old plants have often been abandoned. The newer plants seem now to be designed or should be designed with the idea of progressive refinement to keep the site permanently tenable or as much so as possible. There may be a germ of practical value in this paper, but like building over old houses, to carry it out calls for the rarest of professional talent. Furthermore, I hope the paper will impress you with the live thought to try to make designs so flexible that the innovations of the future may most easily be adopted later in the plants built today.

REMODELING OF OLD SEWAGE TREATMENT PLANTS TO INCREASE EFFICIENCY

DISCUSSION

By F. S. CURRIE*

During the past few years it has been our privilege to design several sewage treatment plants which included in the design the reconstruction and use of old existing Imhoff tanks and other structures.

These include the conversion of an old Cameron tank approximately 6 ft. wide, 6 ft. deep and 100 ft. long at Loma Linda to a primary clarifier and three digestion tanks.

At San Juan Capistrano the old septic tank was converted into a primary clarifier and digestion tanks. Both of these plants include gas collection and burning. At El Monte the existing Imhoff tank was converted into a secondary digestion tank. At Seal Beach the existing Imhoff tank was so badly shattered by the earthquake that its use was not advisable. The disposal plant for the City of Visalia will include the reconstruction of their existing Imhoff tanks into a primary clarifier and secondary digestion tanks. At Delano the existing Imhoff tanks will be converted into digestion tanks.

In most instances the use of existing plant structures as they are

*Consulting Sanitary Engineer.

by adding additional units is not practical, as the standards used in design have been changed since existing tanks were built. Another objection to continued use of Cameron or Imhoff tanks is that packing and other industrial wastes upset the digestion and at the same time interfere with sedimentation. For such wastes, the use of separate sludge digestion is a means of avoiding at least one of these difficulties. In the several jobs I have designed in which old units could be used, a careful study of all uses for which these old tanks are suitable has shown that the Cameron or septic tanks can be converted into rectangular mechanical clarifiers or secondary sludge storage and digestion tanks, while the Imhoff tank is, because of its shape and size, more easily converted into a sludge digestion tank. The use of these tanks is possible only when they are in good condition structurally.

At Visalia a careful analysis of the value of reconstructing and using the present tanks was as follows:

COST OF NEW CLARIFIER AND DIGESTERS

1—65-ft. Diam. by 8-ft. Side depth Primary		
1400 cu. yd. excav.	@ 1.	$1,400
65 cu. yd. 3000-lb. Concrete	@ 18.	1,170
92 cu. yd. 2500-lb. Concrete	@ 14.	1,285
10 Ton Reinf. Steel	@ 90.	900
1—65-ft. Diam. Clarifier Unit with Skimmer		6,000
2—40-ft. Diam. by 25-ft. Side depth Digesters—		
1100 cu. yd. excav.	@ 1.	1,100
266 cu. yd. 3000-lb. Concrete	@ 18.	4,800
95 cu. yd. 2500-lb. Concrete	@ 14.	1,330
22 Ton Reinf. Steel	@ 90.	1,980
Digester Equipment		7,400
Erection & Installation		1,635
Total cost of new Clarifier and Digester		$29,000

COST OF RECONSTRUCTION OF PRESENT IMHOFF TANKS

Clean out Tanks		$ 900
Remove Concrete		2,100
Fill under Primary	—310 cu. yd. @ 1.	310
Primary Floor	—100 cu. yd. @ 14.	1,400
Digester Roof	—140 cu. yd. @ 18.	2,520
Reinf. Steel	— 15 Ton @ 90.	1,350
Heating Coils		730
Gas Holder		1,000
Primary Equipment		3,500
Scum Breakers		2,200
Installation		700
Total cost of reconstruction of present Imhoff Tanks		$16,700
Total cost of new Clarifier and Digester	$29,000	
Total cost of reconstruction of present Imhoff Tanks	16,700	
NET COST of the new Clarifier and Digester		$12,300

From this table it will be seen that the value of the tanks was $12,300. Actually this is not true, as new tanks would be better and easier to operate. However, in several instances, we have found that the City is still paying off bonded indebtedness incurred in the construction of the existing plant, and it is a hard proposition to put over a bond issue for new disposal works when the existing unpaid-for plant is entirely abandoned. Without question its use in the design of the new project sets better with the voters.

Another advantage of using existing structures rather than designing new structures at a new site is that in most instances no matter what is done in the construction of the new plant, the conditions surrounding the old plant will be improved and few, if any, objections from surrounding property owners will be made against the construction of the treatment plant. Incidentally it is doubtful if the Engineering Department of the State Board of Health would have granted us a permit to construct a treatment plant for El Monte if we had not improved the existing plant and conditions surrounding it. Possibly the greatest objection to the use of existing tanks is the problem of the disposal of the sewage during the construction period, the emptying and cleaning of the old tank and its condition determined by a thorough inspection after emptying.

Considering all phases, it is my opinion that the actual value of the existing tanks in the construction of a modern plant is pretty small, but there is no question as to its value in the minds of the voters and the owners. A used car is more valuable to the owner than to others.

REMODELING OF OLD SEWAGE TREATMENT PLANTS TO INCREASE EFFICIENCY

DISCUSSION

By CLYDE C. KENNEDY*

While sewage treatment plants that are outmoded, are perhaps more wisely abandoned than reconstructed, there frequently is a political and sometimes a definite economic reason for utilizing portions of the plants in the new construction. It is much easier to utilize the old treatment plant site than to overcome local objections to a new one. The site already in use probably is topographically and geographically suitable and will require the minimum change in the collecting system.

Where reasonably adequate works exist, they may be made to meet new and unanticipated demands in many instances without structurally changing the existing units. Recent developments in mechanical equipment suggest aids that may be employed, where the present units are inadequate. It is here that an intelligent operator can be of great value, for he has seen the operations of the plant under all conditions and knows where the difficulties lie. Design change may profitably be worked out in the light of such observation.

*Consulting Sanitary Engineer, San Francisco, California.

Mr. Harmon has mentioned the most common and serious fault in plant design: The use of design bases either at the time of design or from subsequent development found to be too low for the conditions to be met. There can be no excuse for the design of a plant without analyses of the sewage load in terms of settleable solids, biochemical-oxygen demand, and the like. Loading in excess of established standards of performance is inexcusable unless the available funds are inadequate to make possible the provision of required size units. In this event the fact should be pointed out to the applicant city of the unproven adequacy of the units proposed, so that no misunderstanding will exist in the minds of city officials responsible for the plant construction. Recent developments in knowledge and equipment hold much of promise for overloaded plants.

Improper functioning of sedimentation units may be improved by pre-chlorination, grease removal, additional screenings removal by fine screens, grit removal and by flocculation, either without or with the aid of chemical coagulation.

Inadequate oxidation units may be made to function satisfactorily by decreasing the organic load and distributing the load more uniformly over the 24 hours of the day. Two definite methods of decreasing the load are available: the removal of greater portions of the load in the sedimentation unit through the use of flocculation and chemical precipitation and the dilution of the sewage to be applied to the oxidizing unit. It has been definitely proven that high grade effluents can be produced only when the loading on the oxidation units is very moderate, say 200 p.p.m. or less.

Proper sludge digestion is possible only with adequate holding period in the digestion tanks. In the case of an overloaded digestion tank an additional tank may be provided for stage digestion, or the sludge may be thickened ahead of the digestion tank as has been done at Phoenix.

When vacuum filters are employed the bulk of the sludge may be materially reduced by elutriation thus increasing the filter rate two or three fold.

In many separate sludge digestion plants the excess supernatent liquor has generally been neglected and sent back into the system with its tremendous biochemical demand (2000 to 10,000 p.p.m.). It can be controlled by separation and special treatment or more simply by regulating the rate of loading so that it can be taken care of at a uniform rate or by special chemical treatment before returning to the plant flow.

With all the aids now available, no plant need be considered wholly obsolete. To accomplish the best results requires a full knowledge of the conditions to be met as well as the processes and equipment available. We are undoubtedly entering an era when the value of technical advice can be more accurately measured by the cost of operation rather than by the cost of the construction. It will be cheaper for cities to pay for intelligent operation than to erect monumental structures.

CONDITION AND SALE OF SLUDGE FOR FERTILIZER

By WILLIAM A. ALLEN*

Conditioning of sewage sludge for sale as fertilizer, as practiced at the Pasadena Tri-City Sewage Treatment Plant, developed as a matter of necessity. At the time the plant was constructed relatively little information was available on satisfactory means of disposing of the surplus sludge from an activated sludge plant, in fact, it was considered one of the more or less unsolved and troublesome problems of this method of sewage treatment. The original plan for the plant was to dewater the surplus sludge to about 80% moisture and deliver it to farm wagons equipped with manure spreaders. The equipment installed failed to give the results guaranteed both as to capacity and moisture reduction, also, the nuisance created from spreading the wet sludge on the city owned orange grove was such that there were numerous complaints on account of odors. After repeated attempts, and an equal number of failures by the manufacturer, to dewater the sludge in accordance with their guarantee, this method of sludge dewatering was discontinued. During the interim between the abandonment of the original dewatering equipment and the installation of vacuum filters the liquid sludge was run on the farm land and later was impounded in beds in the wash adjacent to the plant. Both of these methods had their attendant evils, such as odors and fly and mosquito breeding, and needless to say were the source of many complaints.

About December 1924, two 11½-ft. by 14-ft. vacuum filters were installed, together with the necessary conveying equipment and bins for loading the filter cakes into trucks. A ditching machine was rented and kept in practically continuous use digging ditches for burying the sludge cake from the filters. After more than a year of this method of sludge disposal some of the disadvantages of burying sludge were apparent. After heavy rains the ditches filled with water, causing the sludge to come to the top and creating an odor nuisance which was readily and strongly objected to by residents in the vicinity of the plant. Storm waters coming into the wash caused erosion which exposed the ends of many of the ditches and carried the partially digested sludge down the wash, depositing it along the bank for several miles, thus creating further odor nuisance. Placing brush on top of the ditches before covering with dirt was tried in an attempt to prevent the dirt from settling and allowing the sludge to come to the surface. This was only partially successful and due to continuing complaints a large crew of laborers under the supervision of a state inspector were required to re-cover the ditches where the sludge had worked to the top. It was estimated that more than 50,000 cu. yd. of sludge cake were buried between January 1925 and August 1928 when burying was finally discontinued.

Mechanical drying equipment was installed in 1926 and 1927, the first test runs being made in February 1927. From the start it was very evident that conditioning of the sludge prior to filtration was of vital im-

*Superintendent, Pasadena Sewage Treatment Plant.

portance. When burying sludge the moisture content of the filter cake made little difference, the object being to filter the sludge as economically as possible. When drying was started it was found that with a moisture content of 85 to 87% in the feed to the dryer the results were very poor. Experience then, and since, indicates that the moisture of the dryer feed should not exceed 82 to 83%, lower water content is of course desirable, consistant with an economic balance between coagulant and fuel costs. When using sulfate of alumina as a coagulant, at a rate of 8 to 10 pounds per thousand gallons of liquid sludge, without filter aids, the average moisture content of the filter cake was 83 to 85%. With a dosage of 10 pounds of sulfate of alumina and 10 pounds of filter aid (diatomaceous earth) per thousand gallons, a moisture content of 79 to 80% was obtained. Up to the time the filter aid was added part of the filter cake was dried and part buried, depending on the amount the dryer could handle. The addition of the filter aid enabled us to double the dryer output and eliminated the necessity of burying sludge. While the nitrogen value of the sludge was less with the use of a filter aid, due to dilution, the increase in dryer capacity and tonnage produced, and elimination of burying expense, more than offset this disadvantage, in fact, the cost per ton for the filter aid was less than the price received for the fertilizer and as long as this condition prevailed there seemed no reason for discontinuing its use.

The use of ferric chloride as a coagulant, in place of sulfate of alumina, was started in June 1930. It undoubtedly would have been used earlier had there been a dependable source of supply on the west coast at a reasonable cost. Results obtained with ferric chloride left no doubts as to its superiority as a coagulant; lower moisture filter cake was obtained with a very material decrease in the amount of filter aid used. The use of filter aid was discontinued in 1933, the point having been reached where it was no longer economical, and since that time ferric chloride only has been used for conditioning the sludge prior to filtration.

Several factors have been found of considerable importance in the conditioning and filtration of activated sludge; the time interval between dosing and delivery to the filters should be as short as possible; reaerated sludge requires less coagulant than sludge taken direct from the final settling tanks; suspended solids content of the sludge materially affects the amount of coagulant required, with a heavy sludge the filters can be speeded up, increasing the dry basis output per filter with a resultant lower cost for coagulant due to less water requiring conditioning. Normally our experience indicates that when the suspended solids in the sludge are between 5,000 and 7,000 p.p.m. approximately 200 pounds per ton, dry basis, of coagulant will be required, if the suspended solids are increased to 9,000 to 10,000 p.p.m. 7 to 8 per cent or approximately 150 pounds of coagulant per ton will be required. At times there are other conditions which affect the character of the sludge and result in an increase or decrease in the amount of coagulant required. Type of sewage treated, condition of sludge, method of coagulation and moisture content desired are factors which largely determine the amount of coagulant required.

Coagulation and filtration are but the first steps in our method of conditioning sludge for sale as fertilizer. The sludge must next be dried to about 5% moisture, pulverized and screened to obtain as near as possible a uniform particle size for delivery to the sacking bins. The finished product, marketed under the brand name Nitroganic, is packed in burlap bags containing 100 pounds net weight. Much has previously been written regarding sludge drying and the various difficulties experienced in odor elimination and dust problems and will therefore be omitted here.

Various methods of marketing Nitroganic have been tried, such as contracting the entire output, selling direct to consumers and marketing through a limited number of distributors. The later arrangement has been in effect for the past six years and has been found the most satisfactory. The Purchasing Agent for the City of Pasadena, who is also Nitroganic Sales Manager, supervises the activities of the distributors with regard to the sale of Nitroganic. The retail selling price per ton is fixed by the city f.o.b. our warehouse and no deviation is permitted. The larger portion of our sludge is used by citrus growers, this being one of the largest agricultural activities in this part of the state and consequently the market for our fertilizer is considerably influenced by the citrus market. Users of Nitroganic are apparently well satisfied with results obtained as much of our business is from growers who have used it year after year. We have many customers who have used our product since it was first made and continue to use it even during periods when our price is above the current market for organics. We find, however, that in general the consumer buys fertilizer on an analysis basis and for this reason we endeavor to keep our price in line with other organics. Nitroganic is sold on a guaranteed analysis basis of 6.00% nitrogen, 3.00% phosphoric acid, total, and .30% potash. The average nitrogen content of our fertilizer for the month of July 1938 was 6.65%, the minimum was 6.44% and the maximum 6.86%.

The following tabulation shows the fertilizer prodction, sales, revenue and cost per million gallons of sewage treated for sludge disposal for the past six years.

Fiscal Year	Tons Fertilizer Produced	Tons Fertilizer Sold	Production and Sales Cost	Revenue	Net Cost Sludge Disposal	Cost per M.G. for Sludge Disposal
1932-33	3,169.80	3,848.00	$77,905.19	$40,891.65	$37,013.54	$14.12
1933-34	3,153.95	3,035.00	77,585.17	43,562.06	34,023.11	12.91
1934-35	3,025.60	2,880.45	78,411.52	54,321.25	24,090.27	9.02
1935-36	3,156.00	3,197.95	72,103.79	54,449.96	17,653.83	6.35
1936-37	3,396.50	3,512.75	69,671.23	69,723.36	(52.13)	(.02)
1937-38	3,492.05	2,819.20	76,669.81	62,730.42	13,939.39	4.51

It is of interest to know that for the fiscal year 1926-27, which was the last full year the filtered sludge was buried, the cost for sludge disposal was $54,304.19. The saving in cost for sludge disposal leaves no doubt as to the merit of our present method of conditioning sludge for sale as fertilizer.

CONTROL OF CHLORINATION

By A. C. BEYER*

The treatment of the subject in this paper is an endeavor to present a fresh viewpoint which will serve as a sound basis for a reappraisal of sewage chlorination. An exhaustive consideration has not been attempted, but rather an outline around which discussion of all phases may center.

As a logical approach, it appears well to analyze the basic reasons for sewage chlorination. Sewage chlorination in its fullest meaning is increasingly regarded as covering the use not only of chlorine but of its derivative salts, largely ferrous and ferric chloride. Since the uses of chlorine and of its derivative salts are inter-related, and since their proper application follows along the same lines, all of these chemicals will be given consideration in this paper.

Consideration will first be given to the wide range of applicability as well as to the fundamental reactions of chlorine and its salts in this field. This will more acurately indicate the requirements to be kept in mind when specifying sewage chlorination control equipment.

The actual practical uses of chlorine and its salts have been tabulated so frequently that their repetition is unnecessary. However, it would be well to point out that in view of the possibilities of these compounds, it is desirable to provide opportunities for at least periodical application of chlorine and its derivative products to various points in a treatment plant such as:

a—Influent
b—Grease removal units
c—Flocculators
d—Primary clarifiers
e—Trickling filters
f—Return activated sludge lines
g—Effluent
h—Sludge thickeners
i—Supernatant return lines

Again, instead of listing the actual uses of chlorine and its salts, a much more usable picture of the possibilities in chlorination can be built around an outline of the fundamental reactions in which chlorine plays a part in sewage treatment practice. Undoubtedly all of the past uses of chlorine, as well as the future uses of chlorine, can be grouped under several basic headings, and if these headings are clearly recognized, it will aid individual solution of particular problems not tackled to date.

The basic reactions employed in all sewage chlorination can be analyzed in terms of their true nature and in reference to the chlorine compound used. To W. J. O'Connell goes the credit for the new nomenclature used in this tabulation.

Simple chlorination is always used to effect—

1. STERILIZATION; OXIDATION—which in practice may be for any one of the following specific purposes:—

A—Destruction of Pathogenes (Disinfection).
B—Destruction of Sulphate Splitters.

*District Manager, Wallace and Tiernan Company.

C—Destruction of Acid Formers.
D—Destruction of Filamentous Organisms (Activated Sludge Bulking).
E—Destruction of Organic Coatings.
(1) Pipe Slimes.
(2) Organisms on biological oxidation beds — trickling filters, Dunbar beds, slow sand filters.
F—Chlorination of Grease.
G—Stabilization of Organic Matter (B.O.D. reduction).

Chlorine and either or both of its derivative iron salts can be used for:

II. REACTION WITH SULPHIDES: which in practice may be for—

A—Release of free sulphur
B—Formation of ferrous sulphide

Chlorine or its derivative trivalent iron salt can be used for—

III. ELECTROLYZATION OF COLLOIDS: COAGULATION OF SUSPENDED SOLIDS: which in practice may be for—

A—Coagulation of finely dispersed suspended solids.
B—Chlorination of protein.
C—Formation of ferric hydroxide.
D—Formation of ferric jell in biological units.
T—Granulation of digesting and digested sludge.

If the basic concepts of the reactions of chlorine as outlined above are kept foremost in our minds, the list of uses in practice under each of the three major classifications for chlorine reactions will undoubtedly be enlarged in the light of expanding knowledge and through further research. If the fundamental correlation between all chlorine uses is kept thoroughly in mind we will undoubtedly discover ways toward many improvements in the application of chlorine to sewage treatment.

Before proceeding further it should be pointed out that the use of chlorine, "Scott-Darcey chlorination," and chlorine salts is not to be regarded as a process of sewage treatment in itself. Rather, it is to be considered as a very flexible tool to aid basically biological plants to take care of peak loads. Such peak loads may occur daily or seasonally. In California the large number of food packing and processing plants of various types possibly give us more than our share of peak industrial loads.

A review of the above fundamentals will determine which of chlorine or its derivative salts are required in each case. Usually a combination of them will be indicated. Also there will be a great many cases where the degree of need may not justify an adequate equipment installation to apply any one of the required chemicals, but where the combination of all needs will justify a proper installation of equipment to give an accurately controlled amount of chlorine or either of its derivative salts, applied to several points in the treatment plant. Such equipment is now available and has been included in the design for a number of projected treatment plants in this state. One cannot escape the conclusion that having available chlorine and its derivative products, arranged for multiple points of application, operators could quickly cure

or eliminate many sewage plant headaches.

In the control of chlorination it is essential that sewage flow variations be taken into account and that the control of the application of chlorine and its compounds be regulated to compensate for changes in flow. This can be done manually by resetting feed rates at regular intervals to follow flow changes, or flow controlled automatic equipment can be installed. However, usually such regulation is only adequate for treated sewage of practically constant strength.

In all cases of raw or partially treated sewage it is equally important to take into account the variation in the strength of the sewage as well as in the quantity or flow. Under our average western conditions it is unfortunate by inescapable fact that when the flow is the greatest the sewage is then the strongest so that the increase in the requirments for chlorine or its derivative compounds varies geometrically. Therefore, while a peak flow rate might be only double the average, the greater sewage strength at the time of the peak flow will usually require four or more times the average chlorination capacity; on the other hand, the minimum requirements may approach or actually be zero for weak low night flows. As illustrative of the last point it is interesting to note that our old friend, T. R. Haseltine, now Superintendent of Sewage, Butler, Pennsylvania, applies chlorine and its derivative salts (along with lime) from 7 A.M. to 10 P.M. only, relying on straight biological treatment to take care of the weak low night flow.

To take care of the geometrical variations of sewage strength plus the flow variations, compound time-rated, automatic equipment is essential. Such equipment would take care of variations proportional to the flow, with increases in dosages in parts per million superimposed on the flow controlled variations; the time-programmed superimposed variations would take care of the changes in strength of the sewage based upon studies of strength variations. Such equipment is under active consideration for several plants in this state.

In all probability another type of automatic sewage chlorination equipment will be available as a result of investigation now under way. Such equipment will vary the chlorine dosage in relation to the chlorine requirement, even though this requirement be affected by both changes in flow and changes in the strength or chemical composition of the sewage to be treated.

It is hoped that this discussion will aid in establishing a sound basis for the application of chlorine and its derivative salts, to the end that sewage treatment plants will have fewer "bugs" both literally and figuratively. Those engineers with whom the subject has been discussed have felt that the availability of such a many edged tool—that is, equipment for the proper application of chlorine and its salts to multiple points in the plant—will make it much easier for an operator to take the sewage as it comes and turn out consistently an effluent of the quality required. Similarly odor control and protection of plant structures and equipment will be greatly facilitated. As we all know, we can be sure that the sewage will come—both weak, medium and strong—and particularly strong at the most embarrassing moments.

PATENTS IN DESIGN OF SEWAGE TREATMENT WORKS

By ADELBERT SCHAPP*

Patents covering sewage treatment plants and processes are so numerous that, at the present time, it is probably impossible to design a satisfactory plant answering modern demands without utilizing in some way the teachings contained in different patents and giving rise to questions of infringement.

Our patent system was introduced to promote the progress of science and useful arts and, of course, is intended to be beneficial to the various industries. Although it may at times raise many intricate and perplexing questions, the designer who feels like arguing with the patent system should never forget that if it were not for the patent system many of the modern improvements might not be available at all and that each important patent is probably the result of many years of inventive effort made by some of our brightest and most inquisitive minds.

In preparing plans for a sewage treatment plant, it would probably be futile to attempt, in an effort to save royalties or license fees, to design around existing patents. The better plan is to design, in the light of all the knowledge available, the plan best suited to the existing conditions, keeping in mind the result desired, whether for instance an effluent that may be safely used as a feeder for beautifying lakes and waterfalls as in the Golden Gate Park of San Francisco, or merely an effluent that may be safely discharged into a river, the bay or the ocean.

Many other considerations, of course, enter into it, such as amount of money available, cost of construction under local conditions, sites available, cost of running the plant, etc., all of which are too well known to the sanitary engineer and sewerage expert to require discussion by a patent attorney.

Due consideration should be given, however, either during the development or upon completion of the plans, to patent questions, lest the municipality owning the plant should afterwards find itself in a position where an existing patent presents an unsurmountable obstacle to the operation of the plant. In that case, an understanding may have to be arrived at with the patentee on his own terms, on pains of an expensive law suit and a heavy judgment in damages and profits.

To ascertain whether a proposed plan infringes on unexpired patents a patent attorney should be employed to make a search of the records of the Patent Office and to render an opinion on the question of infringement. To narrow down the issue, the designer should separate, as much as possible, the points, which to his knowledge, are old established practice from those which may give rise to questions of infringements. The latter should be clearly defined to place before the attorney one or more definite issues.

The patent attorney, after studying the issues, will go through the different classifications of the Patent Office which may have bearing on

*San Francisco Patent Attorney; Member of California Bar.

the subject of the inquiry. The number of patents found will probably be very considerable and they should now be carefully scrutinized.

As a first step, the attorney will probably arrange the patents found on each issue in chronological order to get a general perspective of the patent history on the point involved. Next, he may draw a line between the patents that have expired and those which are still in effect, the life of a patent being 17 years from the date of issue.

The expired patents should be carefully studied so as to obtain an understanding of the art preceding the patents still in effect, the general rule being that what is disclosed in an expired patent is open to the public and cannot form the subject matter of a later patent, with possibly a few border line exceptions. A careful study of the expired patents is necessary for the further reason that they often may be used to interpret or limit the scope of unexpired patents.

Approaching now the live patents the attorney will direct his attention principally to the claims of each patent, because the claims define the scope of protection granted by the Patent Office. The scope of the claims in a patent should be commensurate with the scope of the invention. Where the invention is broadly new and constitutes a departure into an unexplored field, the patentee is entitled to broad claims. Where the invention is a mere improvement in a field already crowded the patentee is entitled to limited claims only.

In view of the extreme difficulty of drafting claims which are exactly coextensive with the invention, many patents issue with claims too broad and others with claims too limited. Where the claims are too broad and cover something that was old and known at the time of the invention, the claims are invalid. Where the claims are too limited and fail to give full protection, that part of the invention not covered is assumed to be dedicated to the public. Most patents contain a number of claims, which have independent existence in the sense that each claim defines an invention and may be valid or invalid regardless of the fate of the other claims.

Claims of particular interest for our discussion may be drawn to a process or to an apparatus. A process claim usually involves the recital of a series of steps for accomplishing a desired object, while an apparatus claim recites the combination of parts which cooperate in performing the desired function. In patent language these parts are usually referred to as elements. A few examples may suffice to illustrate the difference.

"13. The process of treating sewage and the like consisting in:

(a) delivering locally to the lower portion of a mass of sewage a plurality of successive increments of infusions of minute bubbles of air,

(b) causing the sewage at the points of delivery of increments of air to rise by the infusion of air therewith, and

(c) causing the sewage freed of the air to fall and come under the influence of succeeding increments of air."

This is claim 13 of the Jones Activated Sludge patent No. 1,247,540 and may be considered a typical process claim. Note, for instance, the entire absence of any reference to physical structure. There is no reference to any tank, or any pipe, or diffuser plates or structural tank

features, but merely a recital of successive steps taken in the treatment of sewage. A genuine process claim is not dependent upon structure and is not anticipated by structure previously known that might be used for carrying out the steps. In its scope it is not limited to structure and it is infringed by anyone who uses the same steps, regardless of what apparatus he may employ.

Another process claim:

"3. The process of purifying sewage or analogous liquids, consisting in:

(a) gradually supplying the crude sewage to a body of bacterial sludge or solid matter,

(b) aerating or oxidizing it while so being supplied,

(c) then allowing the liquid to remain quiescent,

(d) gradually drawing off the purified liquid from near the surface, and

(e) leaving the sludge or solid matter."

This is claim 3 of Reissue patent 15,140, also one of the Jones Activated Sludge patents. It differs in scope considerably from the claim 13 previously discussed. Claim 13 is broader in one respect and more limited in another respect. It is broader because it defines aeration perse, detached from steps preceding and following, and more limited, because it definitely sets forth the three steps involved in the aeration, including circulation and feed back. Claim 3 of the reissue patent is not limited to any particular kind of aeration, but it is confined to the mixing of activated sludge and fresh sewage before aeration, and to sedimentation and drawing off after aeration.

A typical apparatus claim is given as follows:

"2. In an apparatus for purifying sewage, comprising:

(a) a tank

(b) means for introducing air or oxygen at the lower part of the tank,

(c) said tank being of a size above the air introducing means to provide a material-receiving area above and laterally of said means and beyond the direct influence of the air from such means,

(d) the tank being inclined adjacent and laterally of the air introducing means to induce a flow of material to such means from that portion of the tank beyond the influence of such means." Pat. 1,282,587.

This claim should be studied very closely to be appreciated. At the date of the invention each of the elements of the claim may have been old. Probably there was nothing new in a tank with a sloping bottom, or in supplying air from the bottom, or in the size of the tank. The claim seems to be carried principally by the inventive thought of combining these elements in the functional relationship set forth. It is probably this obviousness of the individual elements of the invention, whether physical elements or process steps, apart from their functional relationship, which lulled the sanitary engineering experts into the belief that the Jones Activated Sludge patents would not be sustained against a determined opposition.

While process and apparatus are proper subject matter for patents, principles or laws of nature are not. Invention is a creative act; some-

thing must be created that did not exist before. The discovery of a principle is not a creative act, because the principle had its existence before it was discovered just as much as it had afterwards. But the utilization of a principle, whether new or old, for a useful purpose, may well be invention. This distinction was clearly brought out by the Court in the Activated Sludge case in the following language:

"It is true that Jones' method makes use of the scientific discovery that aerobic bacteria can live and thrive in or about the pores of microscopically small spongy particles of flocculi or zoogloeal matter which in turn can be derived from sewage itself by long continued aeration under appropriate conditions, but that is not the subject matter of his patents. The invention is of physical methods and apparatus for handling, treating and controlling the sewage and the bacterial flocculi in such a way as to promote the development and activity of the bacteria and to bring the bacterial matter into play in a new and different way, and it is upon disclosures with respect to those matters that the claims are based."

Returning now to our examination of the unexpired patents found in the search, the attorney examines each of the claims in all of the patents found and tries to read each claim on the proposed plans. He will probably find that the large majority of claims inspected contain limitations not found in the proposed plans. Each claim is a definition of a process or a structure, and if that definition does not fit the proposed plans, the claim is not infringed. All of these claims are dismissed as being of no particular interest to the question in issue.

But a few claims undoubtedly will be found which do read on the proposed plans. These claims are earmarked for special attention and further investigation. The first question is: Are these claims valid? To determine this point the attorney goes back through the prior art which comprises principally all the expired patents and unexpired patents preceding the application date of the patent by at least two years.

The prior art also includes foreign patents, prior publications, domestic or foreign, and instances of prior public use, in this country. If the claim under consideration can be made to read on any of these prior disclosures, it is invalid and would not be sustained in a court procedure. Here fine, hairsplitting points arise on many occasions, and often the arguments pro and con are so well balanced that even the best legal mind cannot predict with any degree of assurance which way the scales will tip.

Assuming a claim is found which reads on the proposed plans and cannot be anticipated by the prior art, two ways are open to the designer. He may design around the claim or secure a license under it. Designing around the claim may be easy when the claim is limited and the point covered is not essential, but in doing so the designer should be careful because in detouring to avoid one patent he may run into the clutches of another patent.

If the feature covered in the claim is desirable, he should approach the owner of the patent for a license. The designer, no doubt, is in a much

better position to obtain a license on reasonable terms at this time, where he can still change the plans, than at a later time when the plant has been erected and he is more or less at the mercy of the patent owner.

The mere fact that someone has a patent on a process or design feature to be used in the proposed plant is not proof that the inventor or patentee himself may use the invention. This may seem contradictory, but is a natural outcome of the relationship between pioneer patents of broad scope and improvement patents of more limited scope. There seems to be considerable confusion among laymen on this point and the wording used by the Patent Office on the face of the patent certificate does not aid any in dispelling this confusion.

The patent certificate, issued under the seal of the United States Patent Office, grants to the inventor, for the term of seventeen years from the date of the grant, "the exclusive right to make, use and vend the said invention throughout the United States and the Territories thereof."

But in reality the patent does not grant to the patentee any right "To make, use and vend" that he did not have before. It merely prevents others from "making, using and vending" the patented invention. Whether the inventor or patentee has a right to actually use the invention, depends upon different circumstances.

Practically all inventions are improvements on prior inventions. If the original inventor of the wheel could have secured a patent on it and such patent were still in force, all of our wagons, trains, tractors, automobiles and practically all of our machinery would infringe the patent, although over two million United States patents have issued since.

The Patent Office, in granting a patent, does not look into the question of infringement. If an improvement is presented to the Patent Office, which meets the requirements of subject matter, novelty, utility and invention, the Patent Office will issue a patent, regardless of how many prior patents the improvement may infringe upon.

Going back to our investigation, therefore, in which we assumed that we found a patent covering a certain feature of the proposed plan, we must not be led to believe that negotiating a license under this patent will necessarily put us in the clear. Even though we negotiate a license we must still figure on the possibility that when working under the patent we may infringe on some older unexpired patent.

Our investigation of all the prior patents found during the search will go a long way, of course, toward giving us the desired information. But it is still a good policy to make a special investigation directed particularly to this point and the most obvious thing to do is to at least go through the file history of the patent which may disclose certain patents cited against the application that were not located in the general search. The patentee should also be made to disclose whether he or one of his other licensees have ever been threatened with an infringement suit.

There is one danger that it is difficult to guard against and that is "pending patent applications." If the proposed plant is to be strictly up-to-date it will probably utilize the latest ideas available on the subject. It may be safely assumed that at least some of these ideas form

the subject matter of pending applications. But the latter are kept secret and no information is available except through the inventors themselves. Many of these applications will be owned, of course, by some of the larger companies dealing in sewage plant equipment and, if the equipment is bought from such company, the purchase will include a license to use pertinent patents controlled by the company. On patent applications owned by outsiders the designer probably will have to take chances.

Where the proposed plan contains features, which depart from standard practice, the designer should consider the advisability of filing a patent application of his own, not only with a view of furthering his own interest, but also to protect the municipality he is working for.

The nature of the inventions made during a certain time period depends substantially upon the problems presented in that period, particularly in a field like that under discussion where progress is mostly due to scientific research and investigation. Since these problems, in a particular field, are substantially the same or at least analogous throughout a wide territory, it is only natural that the answers will be substantially the same or analogous. This is a simple explanation of the well known fact that widely separated inventors will frequently make the same inventions at substantially the same time through independent effort.

If a designer has incorporated new ideas into his plans, he may be reasonably sure that some one else, in the United States or elsewhere, is working on substantially similar ideas at about the same time. If he fails to file a patent application he may find, a year or two later, that some one else has secured a patent on his very idea and his own municipality may eventually be forced to secure a license and pay royalties to an outsider.

If our designer had filed a patent application, the Patent Office would have declared an interference and the two applicants would have fought out the question of priority on even terms, each inventor being entitled to go back to his own date of conception of the idea, subject to certain rules. But where one inventor fails to file a patent application and finally is hailed into court for infringement of the patent granted to the other inventor he cannot rely on mere prior conception to defeat the patent. Thus, through failure to apply for the patent he may subject his municipality to domination by the patent of an outsider though he was the prior inventor.

All patent applications must be filed in the name of the original inventor. If more than one inventor have cooperated in developing the idea they must file as co-inventors. A city employe has the same right to file a patent application and to own the patent as any other person. If he has developed the invention on the time and at the expense of the City, the latter will be entitled to a shopright, but this in the absence of special circumstances does not interfere with the right of the employe to exploit the invention in connection with other sewage treatment plans.

LEGAL ASPECTS OF SEWER RENTAL LAWS AND CONNECTIONS FROM OUTSIDE TO CITY SEWER SYSTEMS

By HOMER BUCKLEY*

Mr. President, gentlemen, I don't know how much of an authority I am on sewage. In Oakland we just dump ours out in the bay; when the tide is in it is all O.K. and when the tide is out it is just too bad. I think I can speak with some authority as to results and consequences. The subject material that has been assigned to me is possibly not as certain and as fixed as we might like. I don't believe I can give you as definite answers as you may desire. Most of the law is negative in that it tells what we cannot do rather than what we can do.

The topic is divisible into two subjects; first, the "legal aspect of sewer rental laws," and secondly, the "legal aspect of connections from outside to city sewer systems." I will treat them separately.

First, the "legal aspects of sewer rental laws." Under the heading of laws I intend to take up questions of legislative acts and decisions of the courts. The courts sometimes have not been able to agree just what constitutes a law, so for the purpose of our discussion I will define a law to be an enactment of the state legislature or a decision of the court of last resort.

The only act that I know of in the state that gives a municipality the power to levy a sewer rental fee for the use of the city sewer system is an act passed in 1935 and generally known as the "Sewer Revenue Bond Act." This act sets up a procedure for the issuance of bonds for the construction of sewer systems and the borrowing of money from the R.F.C. The act is not available unless you use R.F.C. money. However, the act has some possibilities in that it can be amended and these limitations stricken out, in which case you would have a general act under which a city could construct a sewer system under what is equivalent to revenue bonds. The act provides that in order to retire those bonds the City Council shall fix a fee for the use of the sewer system, and that the fee so fixed must produce an amount of money sufficient to pay for the redemption of bonds, payment of interest, maintenance and repair. But as the law stands today, it is practically useless for any practical purpose because to use it the city must have R.F.C. money; but it does have possibilities by way of future amendment.

We have an act which all of you are acquainted with—the Municipal Corporation Act. The language relating to cities of the sixth class is as follows: "to construct, establish and maintain drains and sewers." Immediately the problem arises as to whether or not a fifth or sixth class city can, under this grant of power, levy and collect a sewer rental fee. This problem arose in the case of City of Madera v. Black, 181 Cal. 306. The City of Madera voted bonds for the purpose of purchasing a then existing private sewer system. In 1914, after the purchase of the system, the City Council passed an ordinance making it illegal for any person to

*Assistant City Attorney, Oakland, Calif.

live in any building unless that building was connected with the sewer disposal system, and provided for a "monthly sewage rate or charge for the use of and connection with the sewer, the rate for each dwelling house occupied by a single family being one dollar, payable monthly in advance on the first day of each month." The ordinance also provided that upon failure to pay the fee, a penalty should be imposed of $10 in addition to the accrued sewer rental, and that the rental should be a debt to the city and could be called by a civil action. A fellow by the name of Black, being an independent sort of a fellow, didn't like the idea, and he refused to pay the fee. At the end of thirteen months the city brought action against him for $13 plus the $10 penalty. At the time of trial Black proved certain things which are very interesting to us, I think. I will state the figures in round numbers. At the time of trial it was proved that the City of Madera had collected under this ordinance some $40,000 in sewer rental fees. Of that amount of money, $21,000 had been transferred to the General Fund of the city, $8,000 had been transferred to the Water Fund and $1,000 transferred to the Sewer Bond Redemption and Interest Fund. Black argued that by virtue of the fact that the ordinance created a debt for the amount of the sewer rental and provided for its recovery in a civil action, that the City was engaged in carrying on a business and was therefore engaged in what is called a proprietary function. He argued that a city of the sixth class had no power to operate a sewer system as a proprietary function, and therefore the ordinance was invalid. The court, in discussing this aspect of the argument stated as follows:

> "If the argument of respondent that it is a debt is tenable, it must be upon the theory that the city, in its proprietary capacity, is the owner of the sewer, and that it was operating the same in that capacity. This necessarily assumes that the city by its organic law was authorized to construct and operate sewers in its proprietary capacity for profit or otherwise, as a private person might do."

In discussing this problem, I want you to keep in mind that in this State we have two kinds of municipalities, those that are organized under the Municipal Corporation Act and those that are organized under a Freeholders' Charter. A city of the sixth class and a city of the fifth class have their corporate existence by virtue of their organization under the Municipal Corporation Act, a statute of the Legislature, and a chartered city owes its existence to a provision of the Constitution. These two classes of cities are very different insofar as the powers that are granted to each; a sixth class city only has those powers which are expressly and directly granted to it. As the court says here:

> "Madera, being a city of the sixth class, its powers are defined solely by our statutes. Among those powers we find none authorizing it to acquire, construct or operate sewers in its proprietary capacity for the purpose of obtaining revenue or profit therefrom. It is given power 'to construct, establish and maintain drains and sewers.'
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> "It is the settled law of this state and the general rule everywhere that 'language purporting to define the powers of a municipal cor-

poration is to be strictly construed' and that any 'fair reasonable doubt concerning the existence of the power is resolved by the court against the corporation and the power is denied'."

Madera is a sixth class city; therefore its powers are defined solely by statute, the Municipal Corporation Act, and such powers are to be strictly construed.

The language I read to you a moment ago gives to the City of Madera the power to "construct, establish and maintain sewers and drains," and the court in the Black case said:

"But it is obvious that the power to construct and maintain sewers does include authority to raise revenue for general purposes by means of a toll or tax for the privilege or right to use the sewer for the purposes for which it was constructed."

Now, then, the only conclusion that can be drawn from the case is that the City of Madera was operating its sewer system as a police power function, as distinguished from a proprietary function.

Now we get to another fundamental principal that arose in the case. If a city is levying licenses for purposes of regulation, that is by an exercise of its police power, the amount of license that may be charged shall be only enough to pay for the cost of supervision and regulation. If a city levies a license in a proprietary capacity or for revenue purposes, the only limitation is that the license must not be so great as to constitute confiscation.

Now in the language I have just read, the court came to the conclution that the City of Madera was not carrying on its sewer system in a proprietary capacity. Therefore the court says the amount of the license that the City of Madera could collect could not exceed an amount of money necessary to pay for the operation and maintenance of the sewer system, and that the use of such license fees for general fund purposes was beyond the power of the city to do. The court uses the following language:

"But the rates here imposed upon the sewer users were obviously for purposes additional to that of paying the expenses of repair and maintenance. . . . This would be an unfair discrimination and unfair burden upon those who use the sewer and it is clearly beyond any power possessed by the city. It follows that the charges were excessive and unreasonable."

The court stated that if any of the license fees taken in for sewer rentals had been used for the purpose of extending the sewer system, such a use would be unlawful. I will continue with the language of the court:

"If any (sewer rental) was used for extensions to the sewer system, such use was unlawful, and it cannot be doubted that the city has no power to lay taxes or tolls upon those who use the sewer in order to obtain money to build sewers in other streets for the special benefit of other persons."

These sewer bonds were voted under the Bond Act of 1901, our general bond act in this state—that is, general obligation bonds. That act provides that a city council shall each year at the time of levying taxes

include an amount of money sufficient to pay for outstanding bonds that are to be redeemed during the course of that year, and an amount of money sufficient to pay the interest on the outstanding bonds. The court says that under that act the method of raising money to redeem bonds and of paying the interest was fixed, and therefore the city council had no power to raise money by way of a sewer license or a fee to meet this obligation. In this regard the court says:

> "The payment of the principal and interest of the bonds issued as aforesaid is to be paid out of money raised by a general tax upon property as provided in the act authorizing their issuance. No money raised by sewer rates would be necessary to pay those bonds or could lawfully be used in that manner."

Therefore we have a decision in which the court has held that the city in levying a sewer license was not acting in a proprietary function but in a police power function, that the amount of the license levied was excessive, that the court would not attempt to determine what a reasonable amount was and therefore set aside the entire amount of the license. The court says:

> "A court cannot apportion the charge or ascertain and allow such portion as it might find reasonable. . . . The entire charge must therefore be declared invalid."

Now that is the conclusion reached as to the law relating to cities of the sixth class.

A chartered city is in a different situation. Under the Constitution, Sections 6 and 8 of Article XI, a city which holds a freeholders' charter is granted supreme power in all "municipal affairs." What a "municipal affair" is has never been completely defined. The courts have on many occasions said, this is a "municipal affair" and this is not; the only definition we have is either by inclusion or exclusion in specific cases.

The courts have said that the power to construct sewers and drains is incidental to the power to construct streets, and the court has held that the construction of streets is a "municipal affair." A chartered city is not dependent upon specific grants of power as is a sixth class city, but is supreme in all "municipal affairs," unless the charter contains some specific limitation. I think the decisions of the courts of this state are sufficiently broad to say that the Constitution provides that the operation and maintenance of any sewer system by a chartered city is a "municipal affair." That being so, then I think a chartered city can levy a license either to pay the cost of operation, maintenance or replacement, or for the purpose of producing revenue for general purposes, unless there is something in the charter that specifically prohibits it. In other words, if the City of Madera had been a charter city, I believe the court would have come to a contrary conclusion and sustained the license.

Now from this discussion, at this point I think we can come to certain conclusions, most of them being negative. The first is that cities of the fifth and sixth class cannot operate a sewer system as a proprietary function; second, that such cities can operate sewer systems only as a

police power function; third, that the money produced by a sewer rental can be used only for the purposes of maintenance and repair of the specific sewer system; fourth, that none of the sewer rental money can be used for the extension of the sewer system; fifth, none of such revenue can be put into the general fund; sixth, it cannot be used for the water fund; seventh, it cannot be used to retire the bonds of your sewer system nor to pay the interest on those bonds; and eighth, that the amount of rental produced must not exceed the cost of operation and maintenance.

Now this brings us to the next aspect of our subject and that is, "city connections from outside to city sewer systems." In this aspect of our discussion the distinction between chartered cities and cities organized under the Municipal Corporation Act is of no importance, because it has been held that when a sewer problem goes beyond the boundaries of the city, it ceases to be a "municipal affair," and becomes a state affair. In such case both classes of cities cannot function unless there is some specific grant of power. It has been argued by some lawyers that the constitutional grant of police power to make and enforce ordinances to protect the public health is sufficient authority to construct a sewer system in a congested unincorporated area adjacent to a populated community in order to protect the health of that community.

The City of Richmond, Virginia, under a similar grant of power, argued:

> "We have here immediately adjacent, a very large residential area without any sewer at all, the resultant condition is so hazardous, the public health and public safety is so affected, that we believe the city should go outside of its limits and construct sewers."

As a result they passed an ordinance providing for the extension of city sewers in unincorporated territory. The matter went up to the Supreme Court of that state, and the court held that under the power to protect the health and safety of the people of the city, it could spend money beyond its corporate limits in order to protect its citizens. In Indiana a city did the identical thing, but the Supreme Court of that state came to a contrary conclusion. What the law is in this state I don't know. I am, however, inclined to the thought that the courts would not approve the construction of sewers by a city outside of its corporate limits upon the theory that it was protecting the health and safety of its own citizens.

In the case of *Mulville v. City of San Diego* (183 Cal. 734), we have an interesting case that throws some light upon the subject matter. In that case the City of San Diego organized an assessment district to construct a pleasure pier which projected from the land out into the ocean. There being no land which could be subject to assessment in the ocean, the assessment area ended at the water's edge. Thus the improvement was to extend beyond the boundaries of the assessment area. The action was attacked upon the ground that the City Council could not construct an improvement outside of the assessment area. The Supreme Court came to the conclusion that the objection was well

founded and held that the city couldn't construct the improvement beyond the area which was assessed to pay for the improvement. This is very analogous to the power of a city to construct a sewer beyond the boundaries of the city which is taxed to pay for the improvement. This quotation is rather long, but I will read it to you:

"In general a municipality is competent to act beyond its boundaries only in those cases in which it is so empowered by legislative authority, and it is necessary in passing upon the validity of acts of a municipality performed beyond its boundaries to look to the general laws and municipal charter for the requisite authority.

"The general rule is that without legislative grant the authority of the municipal corporation is confined to its own area, hence its acts and ordinances have no force beyond its corporate limits. Thus, in the absence of such grant the municipality cannot open a street, repair a highway, grade an avenue, or aid in the construction of a plank road or bridge beyond its boundaries."

In subsequent decisions dealing with sewers the courts have limited the power of the city to go beyond its boundaries to outfalls, and in none of those cases has any city gone to the extent of authorizing or empowering the extension of the sewer system merely for the convenience of adjacent territory. Even the right to extend the outfall beyond the city has been fought over very strenuously. The language just quoted is a definite statement that is applicable to all cities of the state so far as their right and power to perform functions outside of their corporate limits is concerned. This conclusion has been substantiated in the recent case of *City of Oakland v. Brock* (8 Cal. (2) 639). The issue in that case was the power of the city to inspect slaughter houses outside of its corporate limits in the interest of the public health and safety of its citizens who purchased most of the meat slaughtered there. The court, in discussion this question, stated:

"A municipal corporation has generally no extraterritorial powers of regulation. It may not exercise its governmental functions beyond its corporate boundaries. . . .

"The authorities do not recognize extraterritorial regulation and inspection in itself as either necessary or indispensable to a governmental function in such cases."

Now, when you get to the problem of the chartered cities, you get into the realms of your "municipal affairs." An interesting case went up to the Supreme Court of this state a few years ago, arising out of some problems in the construction of storm drains and sewers between an area in the City of Los Angeles and abutting areas in the City of Long Beach. In that case, *Torson v. Fleming* (91 Cal. App. 168), they used an act which has subsequently been repealed, known as the City Boundary Line Act, which set up a procedure whereby an improvement may be constructed to serve areas inside an incorporated city and an unincorporated area or area within two adjacent incorporated cities. In this case the question arose as to whether or not the construction of a sewer was a "municipal affair," and the Supreme Court stated the following:

"Where the evil to be remedied reaches beyond the boundaries and jurisdiction of any one municipality—whether such extra municipal ill be due to an unimproved roadway extending into one or more municipalities, or to unsanitary conditions due to the lack of a suitable regional sanitary sewer system, or to a widespread overflow of rain waters—a proceeding to correct the evil by a single comprehensive scheme of improvement on lands in an improvement district which embraces a portion of all of the municipalities affected by the evil conditions is, as we have shown, more than a mere municipal affair."

Thus the court comes to the conclusion that the construction of a sewer and storm drain that serves territory in two cities is not a "municipal affair," but a "state affair," and that a city has no power to carry on such a project except pursuant to authority granted in specific statute, in this case the City Line Act.

This is practically the extent of the court decisions of this state that are applicable to the particular aspect of this problem. There is a very long series of statutes that provide for the organization of various types of sanitary districts. They provide generally for the Board of Supervisors or the City Council to call an election upon presentation of a petition of a certain percent of the voters. They set up procedures that in most cases require the calling of elections and of a procedure expensive to carry out, and for practical purposes we cannot use them in small areas. There is, however, an act generally known as the Act of 1899, for taking care of this problem of relative small areas adjacent to cities. This act provides that the Board of Supervisors may by resolution, upon petition of a certain percent of the people within the particular area, create a sanitary district, and the sanitary district when created can contract, or rather the Board of Supervisors representing that district can contract, with the adjacent municipality for the disposal of the sewage in the adjacent area. The Board can levy a special tax upon the area benefitted to construct the improvement, and when the improvement has been constructed, the Board can, by contract with the city, provide the terms and conditions under which the sewers constructed by the Board in the outside area can be connected with the city's sewer system.

I do not believe the City Council has the power to construct a sewer system beyond its corporate limits, or that it has any power to permit an outside area to connect its sewer system to the city system, except pursuant to the procedure set up by a specific statute granting such authority. I must tell you again, as I did in the beginning, this conclusion is my judgment; another lawyer may disagree with me; but I think that is the only conclusion you can draw from the statutes and decisions in this state. It is my own opinion that these decisions of the courts are sufficiently clear to indicate this conclusion.

Here is something else I intended to interpolate in the Black case. The court stated that in considering this question they assume:

"It may be that the power to maintain a sewer may carry by im-

plication the additional power to levy a monthly charge to raise money for the repair and upkeep of such sewer. . . .

"A court cannot apportion the charge or ascertain and allow such portion as it might find reasonable assuming but not deciding that the city under its organic law is authorized to impose regular charges for such repairs and maintenance."

Now from that language I would say that the court was expressing ome doubt as to the inherent power of a city to levy a sewer license, nd it is possible that the cities of this state have no inherent authority o levy a license for the use of a sewer. At least the courts have not said hey have. It is my opinion, however, that when this question is squarely resented, the courts will hold that a city can exercise the function of ollecting sewer licenses to operate and maintain a sewer system. How-ver, the court in the Black case cast a very serious doubt upon that uestion.

Now in conclusion, may I summarize. It is my opinion that:

1. Cities of the fifth and sixth class can levy a sewer rental fee for the purpose of operation and maintenance of the particular sewer. This conclusion is, however, subject to some doubt.
2. Cities of the fifth and sixth class cannot levy a sewer rental fee for revenue purposes.
3. Cities of the fifth and sixth class cannot levy a sewer rental fee for the purpose of extending a sewer system or for the construction of another sewer—see the Black case.
4. Charter cities that are generally empowered to construct public utilities can levy a sewer rental charge either for revenue or for operation and maintenance.
5. No city has the inherent power to construct a sewer beyond its boundaries for the benefit of adjacent territory.
6. No city has the power to permit adjacent territory to connect its sewers with the city sewers, except as such connection may be made pursuant to some specific statutory power.

LEGAL ASPECTS OF SEWER RENTAL LAWS AND CONNECTIONS FROM OUTSIDE TO CITY SEWER SYSTEMS

DISCUSSION

Mr. R. F. Goudey (Los Angeles) : Now, one at a time, please.

Mr. W. T. Knowlton (Los Angeles: Mr. Buckley's remarks were very interesting. As far as I know in chartered cities, we have no decision in regard to the matter of the sewer rental fees in this State, although some of the other States do. Therefore, until the matter is adjudicated, I presume it will be all right for chartered cities to proceed on the sewer revenue basis.

Mr. Homer Buckley (Oakland): I think so. A chartered city has right to engage in any proprietary function which includes sewerage. would say unless there is some restricted language in the charter, th a chartered city has power to carry on and charge a fee for that functio

Mr. Knowlton: I just wanted to ask. We have opinions from atto neys which confirm what you just said: that revenues can be obtain that will not in any way be in conflict with the State laws.

Mr. Buckley: Still again a matter of judgment. Most of what I ha said to you is mostly an expression of opinion. The courts of this sta have not squarely passed upon the question but I think the answer very obvious.

Mr. H. W. Jewell (Los Angeles): Would it be necessary for an atto ney to have that Act adjudicated by the Supreme Court?

Mr. Buckley: It would not be necessary. I would have no hesitanc in telling you that in my opinion a chartered city has full power to lev a fee upon persons using the sewerage system and not only that, bu the money derived therefrom can be used for General Fund purpose but my answer as to Fifth and Sixth class cities would be no.

Mr. Jewell: You mean as far as the rate charged?

Mr. Buckley: I think that would have no question.

Anonymous: May I ask if a regular bond could be issued so it woul not come on the taxes, that is the Garrison Act?

Mr. Buckley: Well, I don't want to make an answer and have you de pend on it because I am not well enough acquainted with the details o the Garrison Act. As I understand it generally, it would include that situation. I speak of that with less acquaintance than any other subject matter but I think my understanding of the Garrison Bill is, that you can use it for any utility purpose if you have the legal authority to per form a proprietary function, if that is so you can use the Garrison Act for that purpose, but I don't see any purpose in using the Garrison Act because you have to call an election for the issuance of the bond. The Garrison Bill is intended to permit revenue bonds to carry out a power that is vested in a City, if a City has no power to construct a sewerage system as a proprietary function, then the Garrison Bill would be of no assistance.

Anonymous: If any tax was collected a man could sue for his money back under that decision?

Mr. Buckley: I wouldn't want to answer that, that is the reason a lot of these things are collected, it is sometimes cheaper to pay than to fight.

Anonymous: I would like to ask if this paper will eventually be published in the *Western City*.

Mr. Goudey: It will be published in full in the *California Sewage Works Journal*, whether or not it is published in the *Western City*.

Anonymous: I would like to ask whether in general this language applies to municipal water systems that operate outside of its own boundaries in the Fifth and Sixth class cities?

Mr. Buckley: The court recognizes a different problem in the water situation. Our problem here is, whether or not authority exists in the

city to do the particular thing when you have constructed a water system, it is because you have been granted authority to go into a water business. If I can draw the distinction, when we are talking about sewers we are talking about fundamental powers being vested in Fifth and Sixth class cities, there is no question but what a city has power to operate water systems. If you have an Act where said cities of the Fifth and Sixth class are granted the power to operate a sewerage system outside of its limits, you have no problem. The Legislature has said you have power to operate a water system but never said you have power to operate a sewerage system, beyond the City's corporate limits.

Mr. C. C. Bonebrake (Orange) : In our particular case could we exact such rental from all sewer users for the purpose of raising revenue for the rebuilding of an outfall sewer?

Mr. Buckley: Let me answer your question this way: it would be vastly easier to finance it from your taxes.

Mr. Bonebrake: It so happens some of the territory is taxable but it is not connected with the sewer while if you exacted a sewer rental law, those people who use the sewer would pay.

Mr. Buckley: You have your outfall sewer in now and it has to be rebuilt, my own offhand opinion would be no. I would say yes if for the purpose of maintenance and repair.

Mr. Bonebrake: What is maintenance and repair?

Mr. Buckley: When reconstruction ceases to be reconstruction and becomes entirely new improvement is a big question. Where those two border lines come together I would not dare to say but in my offhand judgment you could levy the license to maintain and keep the sewer in repair, but you could not to put in an entire new construction.

Mr. J. I. McBride (Santa Ana) : The City of Santa Ana proposes to raise the necessary funds to rehabilitate the outfall sewer system by increasing the water rates rather than by raising the money by a tax against real property, which method would be an unjust tax burden on a large area of agricultural properties within the City limits.

Mr. A. K. Warren (Los Angeles) : I think there are a number of cases where the building of sewers by cities, whether chartered or Fifth or Sixth class cities, has been held to be a municipal function not at all subordinate to even the building of streets. The case of Madera should be considered in all of its aspects in that there are certain conditions found there that may not exist elsewhere. First, the Court finds that the Sixth class city cannot collect fees from a certain group to extend a sewerage system into an unsewered area. I thing probably that would hold water. But because at Madera the sewerage system was actually built under the 1901 Bond Act and the payment therefore was expected to be made under that Act, the Court found it improper for the city to utilize revenue funds for the payment of part of the construction cost, interest or bond redemption. I think also that the Court finding that a city of the Sixth class could not operate and charge such a facility so as to provide money for general purposes or general fund, was a proper thing. The question decided was not whether or not a Sixth class city had the right as a municipal function to make charges or

collect fees under its police power to not only maintain and operate a sewerage system, and to actually extend the particular system into new territory, but that because the City of Madera had proceeded under the 1901 Act, the city had no right to collect additional fees for that purpose. I think this particular point should be given some consideration as it differs from other conditions that might arise. The speaker suggested that the Sanitary District laws of the State of California were inadequate, cumbersome or expensive to operate, I think that goes a little bit too far. We all know there are some sixty or more Sanitary Districts in the State which have functioned in a very satisfactory and simple manner under the Sanitary District Act of 1919 and 1923 and also the County Sanitation Act of 1923. The County Sanitation Districts are confined almost entirely to Los Angeles County. Both Acts provide for the incorporation of a district to include municipal as well as unincorporated territory. There are several Acts on our statute books providing for the building of sewers by one jurisdiction in another jurisdiction; one of them the Joint Sewers Act which provides that a city or two cities may join together in building a joint sewer to be used by both jurisdictions.

The 1911 Boundary Act was intended primarily for the construction of streets, pavements, sidewalks, but that Act provides for sewer and water lines. The County Improvement Act, I believe now either directly or by reference to the 1911 Improvement Act, provides that a County may include in a district municipal territory and by the same power a City Council may include unincorporated territories for the building of a sewer system and assess the property benefitted.

Going back to the municipal function of construction and maintenance. Just recently a point has come up which may be of interest to you in that the State Highway Commission has taken a position of supremacy in the matter of control of the State Highways and removal of existing improvements for the regrading or repaving of streets within cities. They have the opinion that all public utilities necessarily will have to make their pipe lines or conduits conform to the new street grade at the expense of the private corporation. Now the State Highway Commission has extended that policy to take in sewers of Sanitary Districts or County Improvement Districts for the reason, I think, of the opinion rendered in connection with a water pipe line of a municipal water system where the municipal water system was held to be a proprietary function, not a governmental function, and as such was in the same category as a utility operating its own line.

In the case of sewers, however, we feel it is a municipal function and not at all subordinate to the construction and maintenance of the street, therefore we hold that any improvement of a State Highway which interferes with a sewer system should replace that sewer system. This matter is now before the State Highway Commission in the change of some of our lines, but I believe other cases will be established to indicate that the building and operation of sewers is a municipal function with the same rights and powers as paving of the streets. Although the speaker did not touch upon it and I don't wish to give it as any other than my own thought, I believe that under the police powers a city of the

Sixth class might possibly have the power to build, operate and maintain a sewer system under proceeds from a fee charged even though it may not be able to extend it with that source of income into new territory.

Mr. Jewell: Mr. Buckley, do the revenue bonds necessarily fall outside of the jurisdiction of limitation? Are they beyond the municipality's General Obligation Fund? The reason I ask is that I noticed a decision in Utah where it was ruled that the revenue bonds would not be considered as General Obligation Bonds.

Mr. Buckley: I think under the Garrison Act, that provision is applicable to your General Obligation Bonds. The thing I have tried to impress upon you is, that many of these matters are based upon your own experience. I think I have the better of the argument. There is a wide field in here that allows for a lot of experimentation. Some localities may levy a license and collect money for a while. My answer is, if you want to do it, go ahead and find out if you are right or wrong. That is the only way you can get the answer to some of these things. If you are wrong the court will tell you so and you can quit and if you are right go ahead. That helps the City Attorney out a lot.

Anonymous: Wouldn't it be a better method to have a committee of this organization go into this matter and draft suitable legislation to correct these things.

Mr. Buckley: You have a legislative policy committee of the League. If this body wants something of that type, I think you can take it up with the Board of Directors and go into the problem, that is if you want something done. Some of you may think that the power is already sufficiently broad now to go ahead and do some of these things, so go ahead and do it, that is the way to find out.

Mr. Goudey: It is time to call this discussion ended. I will declare a one minute recess.

DISPOSAL OF NON-POLLUTED WATER FROM COOLING SYSTEM

By JEAN L. VINCENZ*

Last spring in an article published in *Western City* under the title "Air Conditioning and New Water Use Problems" I attempted to call attention to public officials that air conditioning and air cooling are here to stay and that problems presented by them must be recognized and met intelligently. So rapid has been the adoption of air conditioning and air cooling in some communities that, were it not for the fact that the manufacturers are fully aware of the problems presented to the public officials and are definitely attempting to cooperate with us, many communities would find themselves in embarrassing situations.

The statement has been made that the use of air conditioning plants in the United States has increased 1400% in the five years since 1933. Undoubtedly, the increase for 1938 will exceed any of the previous years.

In some communities water supply is what causes the shoe to pinch, inasmuch as an air conditioning plant of two-ton capacity in a home, operating an average of ten hours only per day, will use 54,000 gal. of

*Commissioner of Public Works, City of Fresno, Calif.

water in a month, or 1800 gal. of water per day. Those cities whose water systems are 100% metered, will have little trouble with this problem, provided their rate schedule is satisfactory.

In the matter of water supply, one should not overlook the many home-made air cooling devices (note "air cooling" instead of "air conditioning") that use from small to very large quantities of water. As an example of this latter, may I site one experience in the City of Fresno that occurred during the summer of 1937. Unfortunately for efficient management of our municipally owned water system, all homes are on a flat rate. At the particular house in question, when the tenants moved out last fall, the landlord found he had to replaster as well as repaper many of the rooms adjoining the bathroom. Investigation revealed that the tenants—a man and his wife, both of whom worked, found the house was cooler when they returned in the evening if they left the shower in the bath room running all day long.

As a further preamble, may I emphasize that I strongly believe not only is air conditioning here to stay, but it is going to become nearly as uniform in some cities as are electric ice boxes. Some of our California cities, of course, are blessed with a climate that does not require air conditioning and yet I believe it will be found in a short time that all of the public auditoriums, at least, will be air conditioned. In our city and in many others, air cooling is becoming so popular and so much an essential part of the household that it seems it will soon be installed in a majority of the homes. A number of rather efficient, small air cooling units are on the market that retail close to $50.

Concerning the disposal of the water from cooling systems, may I state again that the average air conditioning equipment of two-ton per day, based on a use of 10 hours. Compare this amount of discharge into the sewers with the estimates that you use in the design of sewer systems and see where it is leading you. On this basis, how many installations in a block will it take to double the present discharge into the sewer main? Not very many!

Using the above figures, you can readily compute the additional load that will be brought on the sewers of the down town section by the installation of a number of commercial air conditioning units in one block.

This preliminary then, brings us face to face with the problem we desire to consider particularly in this discussion—that of the "disposal of non-polluted water from cooling systems."

It must be recognized that conditions vary so greatly, not only in different cities, but in different sections of the same city, that it is impossible to set down one or two rules and say: "This is the final answer." Suggestions only can be given here which may be discussed and given some consideration and which it is hoped may be of some help in the different communities. My recommendation is that everything possible should be done that can be done to encourage the use of cooling equipment which is economical in the use of water. In air conditioning equipment, these results are being obtained by the use of either a cooling tower into which the water is recirculated, or by means of an evapora-

tive condenser. As stated earlier, the manufacturers are fully cognizant of these problems and are cooperating splendidly. Their salesmen are pointing out that, inasmuch as a recirculatory unit will use only about 5% as much water as the same air conditioning unit without recirculation, it does not take long to pay for the recirculating unit out of the savings on the water bill. The use of a recirculating system in a home is not so simple inasmuch as a cooling tower does not add to the attractiveness of the home, but an evaporative condenser can be readily installed in the basement. The ordinary units are approximately the size of a furnace used to heat the home. If water for cooling equipment is charged for on a flat rate, some credit must be given to those units which use the recirculation system in the home, in order to encourage their installation.

In some cities, or at least in some portions of some cities, a very simple solution may be to have the discharge from the cooling system connected to the storm sewers. This might work particularly well in those communities where there is little, if any, rain during the warm months. However, caution is urged in studying this suggested solution, inasmuch as there is a growing tendency for commercial air conditioning installations to be used twelve months out of the year and difficulties will then arise when cooling water is discharged into storm sewers that are already filled from a heavy rain fall.

Much study is being given to the matter of the return of cooling water into the ground. We have one such installation in a large office building in the City of Fresno, which is working very satisfactorily. In this case, all water for the entire building, other than for air conditioning purposes, is purchased from the city's water department. The air conditioning system has two wells located approximately 75 ft. apart. One is the supply well—the other the return well. An attempt is made to return the water at a different level from that at which it is supplied. The city ordinance requires that such a return well cannot be located closer than 500 ft. to any well, the water from which is used for domestic purposes. This may be an unnecessary precaution. A set of plans showing the proposed installation must be submitted to and approved by the engineering and health departments of the city and the health department, particularly, inspects the job to see that at no place can the water come in contact with the air, or in any way become contaminated. In the system just mentioned, the water flows entirely through pipes and coils. All of these precautions may not be necessary, but in considering such a plan, it is well to think of them. In many communities, there will be no difficulty at all in the return of water as above described, particularly where the water strata consists of fairly course gravel and is not located at too great a depth. In districts such as these just described, return wells from air cooling units in homes might be given some consideration, but only after very careful study by the local health authorities.

Many home owners have suggested that their air cooling units might be connected to their sprinkling system and the water made use of in that way. They overlooked the necessity, however, of having pressure

in the sprinkling system, though it is possible, with a storage tank and small pressure pump, to dispose of the water in this manner.

Those cities which are blessed with having nearly 100% of their streets paved and an adequate storm sewer system, might be willing to give some consideration to allowing the cooling water to be discharged directly into the gutters. This might be quite satisfactory—particularly, if the streets had a fair grade.

Referring again to the disposal of cooling water on the lawns or on the shrubs located on the premises, this is a practice that would have to be watched very carefully in my opinion, for so many varying factors must be considered. In sandy soil, a reasonable flow of water could probably be absorbed satisfactorily—particularly where the flow was not continuous through a twenty-four hour period. Such a flow onto a clayey soil would undoubtedly result in the formation of stagnant ponds, which would be excellent mosquito breeders. In sandy soils overlying hardpan stratas, experience has shown that the water will travel on top of the hardpan strata and soon be finding its way into adjoining basements. Many of you may care to give consideration to the discharge of this cooling water into fish ponds.

Another suggestion that may be worthy of consideration is the discharge of the cooling water into loosely laid tile, such as is laid beneath the surface of the ground for the disposal of water from septic tanks or cess pools. Here, again, it is well known that certain types of soil will absorb the sewage water from septic tanks very readily, while other types cannot do so. I believe, however, that this suggestion merits considerable study. Such an idea then brings us to the thought of the construction of a cess pool to be used only for the reception of non-polluted cooling water. In this case, great care must be taken to be sure that no polluted sewage is connected to the cess pool. With a properly constructed cess pool, together with the necessary drains therefrom, a great deal of cooling water could be taken care of satisfactorily under many conditions and, as I have just said, and I believe it bears repeating, this system deserves considerable study.

As stated in my article of last spring, the City of Fresno has operated, during this summer, under an ordinance requiring that all cooling systems of greater than six-ton capacity must be equipped with a recirculating system. This ordinance will be amended during this winter to provide that cooling equipment of three-ton capacity or greater, must have a recirculating system. We haven't the final solution for equipment of smaller capacities, but we are struggling toward the light. They say he who realizes he does not know it all has a chance to learn. I am definitely hopeful that the discussion that will follow will be helpful to all of us.

In summing up, may I point out that I realize the impossibility of giving you an absolute solution to this problem for every community. However, I have attempted to give you a number of thoughts that have occurred to me, as I have worked with this problem. Undoubtedly, you will think of many other ideas and it is my hope that these suggestions will provoke much discussion that may be helpful, as it may

suggest ideas to you, which you can develop satisfactorily—particularly for your own locality. I feel, however, that I cannot too strongly emphasize the need to encourage the use of the recirculating type of air conditioning equipment and the type of air cooling equipment that is most economical in its use of water.

AIR CONDITIONING—DISCUSSION

Mr. Goudey (after recess): A great many cities have been finding out recently that the large volumes of water required for air conditioning, constitutes quite a tax on sewer systems. We have today Jean L. Vincenz, Commissioner of Public Works of Fresno, a city that has been confronted with this problem, therefore he speaks from first hand knowledge.

Mr. Jean L. Vincenz (Fresno): I am going to speak to some of you that come from those blessed cities that require no air conditioning, and to give you a bit of warning. We who are used to air conditioning, air conditioned homes, air conditioned hotels, stores, offices, you can't imagine how uncomfortable we are in some of your Los Angeles and other city office buildings, hotels, etc., and if you think that isn't going to create a demand for air conditioning in this type of homes and buildings, you are mistaken. I am not the son of a prophet but I am willing to bet as much as a nickel, that sometime you people who are crowing about having ideal climates are going to be confronted with an air conditioning problem. Naturally you are not going to have the same problem as some of the inland cities but if you think you are not going to have it, you are wrong. May I say that in the City of Fresno which is no criterion at all but allows me to speak first hand, all but one of the office buildings are now air conditioned and that one is having an air conditioning system installed right now. In other words, to keep up with competition, every one of the office buildings have had to put in air conditioning equipment after they have been built.

Mr. Goudey: The meeting is open for questions and discussion.

Mr. R. R. Ribal (Oakland): Mr. Vincenz said to me, "I am kind of ashamed of not being well prepared upon this paper." I don't believe any one in California has given half the thought to this subject that Mr. Vincenz has, and I doubt that any one back East has given more. I think Mr. Vincenz has suggested more ways to take care of the used water from cooling systems than any one else in the country. I think this is really a contribution to this new and going to be troublesome problem in California.

Mr. Knowlton: Just one point, your reference to the disposal in paved streets, in our city we have had considerable experience in those matters and considerable complaints with the result that we have had to put this waste water into storm drains.

Mr. Vincenz: The reason I made this suggestion is that it might work in some places. I have noticed the running of water down the gutters from creeks and streams in Salt Lake City, and it has a very good effect. I know it wouldn't work in Fresno. However, there might be some cities in the United States where it might work, that is the reason I suggested it.

Mr. H. W. Hincks (Pasadena): Our city is preparing an ordinance prohibiting the disposal of air conditioning water of plants of three tons or over into the sewer system. The circulating system of standard units come equipped and are cheaper to install as a rule with a water circulating system, therefore I think it is up to the cities to pass some kind of regulatory measure in which it will determine how much water is to be permitted to go down the sewers. In our city it would be rather expensive to allow a large quantity of water to go into the sewer so we have prevented it by not issuing a permit to run cooling water into the sewer. Soon we hope to be backed up by an adequate ordinance, perhaps this month. In regard to the small home sized units, we find the factories are willing to cooperate by providing condensers at a little higher cost. This will eliminate cooling towers which seems to be the principal objection in a residence to recirculating cooling water. Another preventive to large installations in our city is a high water rate. To operate the equivalent to a two-ton capacity cooling system would cost $9.60 per month for water.

Mr. Vincenz: For those of us having flat water rates, that amount of water would be used without paying anything extra. We have, however, put a charge of $1.00 per ton on cooling systems for the first five summer months, which is $2.00 a month compared with your $9.60. We suggest you give consideration to a cooling water charge because if they use $9.60 worth of water they will have your water system working over time for a few months of the year.

Mr.Goudey: Mr. Vincenz, have you ever had the experience in Fresno of taking the water from the distribution in a closed system for cooling and then putting it back into the city mains?

Mr. Vincenz: When the particular large building I spoke of was making an installation, which was one of the early units, they wanted to return the water to the system because they had heard that Riverside was using that system successfully. I believe that one or two cities in Arizona were doing the same thing, however, we refused to allow it because the main reason for using the water of course, is for cooling and when they put it back the temperature is around 96 or 98 degrees and that wouldn't be helping any. It certainly isn't a final solution though in some instances I believe it might possible be all right provided you inspect the system and make sure there are no leaks whereby contamination might enter the water system. We wouldn't allow it and don't intend to.

Mr. F. J. Rossi (Modesto): We are having a somewhat similar problem in Modesto. Our largest problem is taking care of makeshift cooling systems that are put in by the individuals themselves, consisting of a box filled with excelsior through which they run water. They do not provide a cut off valve. When the equipment is shut off the water continues to run. I need not say we are also on a flat rate. We are doing all we can to demand that a cut off valve be supplied. We have a problem there, and don't know just how to take care of it.

Mr. Vincenz: This excelsior pad is quite a thing. You would be surprised to find how much cooler you can get a room by seeping some

water through an excelsior pad with a fan on the other side of it. The excelsior pad picks up quite a lot of dirt and dust in the course of two or three summers. This was reported to our Health Department and our Health Officer upon inquiring found that it was a swell idea because it strained the air. So you see some of the inventions being used in home made equipment are wondrous and marvelous. You will want to keep your eyes on them, for you are going to be surprised what can be done with an old Ford radiator by running some water through it. There is a welding plant in our city that has space of about three times the size of this room, and of course in electric or acetylene welding especially in the summer, gets pretty warm, so a particularly inventive genius, the owner of the business, invented a little home made air cooling equipment, operating on only four gallons of water a day which keeps the whole shop about ten to fifteen degrees cooler than it would otherwise be. Naturally he re-circulates the water. He has something there, for it actually operates on four gallons of water a day. There is no outside connection to the water system; he pours it in out of a five gallon container so that he knows exactly what he puts in.

Mr. Goudey: There is an experimental device consisting of calcium chloride alternately wet and dehydrated that will probably be modified for automobile air conditioning. I think eventually we are going to get further away from the large use of water.

Anonymous: I think Mr. Vincenz is a little bit unnecessarily worried except for the immediate future. I have had quite a little experience with the Mason Building as you probably know. I have represented the owner for a number of years. Seventeen different designs for that building were made before we finally put in the system that is in there now. At the present time, in the early stages of air conditioning, owners are not wise to what they are doing. They are looking simply at the installation and not the operating cost. Most of the equipment going in now is put in at the lowest initial installation cost without regard to future operating cost. When owners find out what operating costs are and that they are unable to obtain renters that will justify an increased operating cost of the air conditioning systems, they will search around for means to reduce the cost. I think ultimately there will be a movement toward conservation of water. We will eventually come to the place where the weaknesses of the present initial cost, high operating cost systems, will cure themselves.

Mr. Vincenz: I think we all agree with you on that. The large units must provide recirculating systems, a condition with which the manufacturers are cooperating. The real problems are going to be with home installations. You know without figuring how many units of two-ton capacity in one block will surcharge your six- or eight-inch sewers. This is the real problem and something that you can't take care of easily. However, it is one of the things you have got to face.

Anonymous: I would like to ask if you have ever considered separate meters in buildings.

Mr. Vincenz: Separate meters are used more or less extensively in the eastern cities, I understand it is an effctive method of arriving at

a solution of this problem where you have 100% metered water system. Many cities have gone through these troubles and have solved their problem by charging a higher water rate for cooling system use.

Mr. Goudey: We are going to call this discussion at an end and thank the speakers, Mr. Schapp, Mr. Buckley and Mr. Vincenz, for the splendid papers they have presented and if any of you have a particular question, you may ask it directly of the speakers after adjournament. We stand adjourned.

NOTES

SELECTED FROM THE CORRESPONDENCE OF THE SECRETARY

THE OLD YEAR saw sewage treatment plants go into use at: Barstow, Chowchilla, Healdsburg, Jackson, Lakeport, Petaluma, Placerville, Shafter Sanitary District, Tehachapi, Tulare Camp of the Farm Security Administration, Willits and two plants at Shasta Dam, one for the Reclamation Service and one for the Pacific Constructors, contractors on this huge project.

THE NEW YEAR finds a number of new plants rubbing their eyes. The list includes: Bakersfield, Brentwood, Chino, Dixon, Imperial, King City, Manteca, Mountain View, Redding, San Leandro, Decota, Carmel, and perhaps others.

THE ANVIL CHORUS

There is a lot of hammering going on at the sewage plants being erected at:

San Francisco—This is a highly mechanized clarification and digestion plant that will hold its own anywhere in the country. The plant is almost completed and warrants your visit when in San Francisco.

Covina—A bio-filter plant with appurtenances on an orange grove at the edge of town and having more gimcracks to harness odors than you ever saw.

Santa Paula—Another bio-filter plant out of town a ways to give some 2,000 people a breathing spell from the sewage odors arising at the old plant. You will remember the old Imhoff tank and sewer farm was wrecked and practically washed away in the March floods of 1938.

Delano is streamlining its old Imhoff tank into a mechanically operated clarifier and digester.

Visalia (where we will meet in April) is also streamlining its Imhoff tank and adding a trickling filter capable of use as a high-rate filter.

Showing that persistence wins **Carmel** contributes a new sewage treatment plant to finally remove sewage off of one of its beaches. The new plant consists of mechanically operated clarifier and digester with the addition of a Scott-Darcy unit for chemical precipitation and odor control.

Decoto is pretty well along with a sewer system and Imhoff tanks. A feature of this project is the laying of a separate sewer line to handle cannery waste and thus keep it out of the Imhoff tank.

A new sewer system and separate sludge digestion plant should be nearly completed at **Coachella Sanitary District**, home of Coachella dates and Coachella grapefruit, on the desert.

UP THE LADDER TO FAME

The State and the San Francisco Water Department lose a faithful and talented sanitary engineer in the departure of **Frank E. DeMartini**, who left the Water Department the first of the year to join the stream pollution arm of the Public Health Service at Cincinnati in a responsible position under H. W. Streeter. That's jumping several rungs at a time, Frank, and more power to you. Don't forget to come back to California some day. "We'll be needing you."

Ted Gregory, formerly superintendent of the Palo Alto sewage treatment plant, is again messing in sewage—this time as resident engineer on construction of the new sewage plant at Covina.

Fred Post was elected president of the San Joaquin Section of C.S.W.A. The organization of this section resulted from a School for operators conducted by Wm. T. Ingram last year.

Henry J. Ongerth is now Junior Sanitary Engineer for the State. Henry was previously Sanitary Engineer, Monterey County.

Joe Sanchis is on leave of absence from the Los Angeles Bureau of Water and Power to consult with the Venezuelian Government in Caracas on water treatment.

Harold F. Gray ably represented the west as a member of the Research Committee of the Federation of Sewage Works Associations for 1938.

H. J. N. Hodgson, formerly a member of this Association and whom many of you met a year or so ago, has just published a report upon his world studies of sewage treatment and which report is an extremely valuable treatise on the subject.

BY WAY OF VARIETY

A Riddle. A. J. Castro, Jr., superintendent of the Santa Clara sewage treatment plant, reports that as a result of frequent analyses at his sewage plant in 1938 he finds that when the peach cannery operates he has only 25% as much sludge per unit volume to put in his digester as during other months. Three guesses where the 75% goes to. Operators having cannery wastes not allowed to answer.

Christmas Present. Know what Chief Gillespie got on his Christmas tree? A little bottle of perfume with directions on how to use it on Oakland's Western Waterfront—the Gardenia Garden, as it is known. Gillespie tried it in the office and it—the perfume—is declared to be a good deodorant.

Arizona: The Arizona Water and Sewage Works Association for the first time since organization, with a Fall Meeting December 10, 1938, launched a two meeting per year program.

A Recommendation: Harold F. Gray, L. H. Taylor and R. R. Ribal on the way to Santa Barbara from Oakland inspected sewage treatment plants at Gilroy, Salinas and San Luis Obispo, and recommend this practice to all of you. We believe it not only instructive, but also helpful toward creating new interest and better maintenance. The Gilroy plant is located in an orchard surrounded by a high wire fence over which we climbed, risking the trousers. The plant enclosure is nicely planted with flowers and shrubs and was operating well, except that the bar rack had not been cleaned, which job of operation we performed. A good many sacks of garlic were stored in the pump house; however, this attempt to camouflage odors was not necessary as there was little offense about the plant.

The Salinas plant was immaculate and operating perfectly. It is easy to understand why Salinas won the Award Plaque in 1932 and most gratifying to find the high standard of maintenance and operation being maintained. The hand rails, floors and equipment were so clean that after climbing around the plant for half an hour a microscopic examination could not have discovered soil on the hands or clothes. Our hats are off to the operators.

After the above two plants, the plant at San Luis Obispo was rather disheartening. The plant is located in an alfalfa field. Just a few shrubs and flowers would greatly improve its appearance and lend a little more life to the plant than did the huge sleeping dog. The bar screens had not been cleaned for several days and all the sewage was going over the top of the screens. After raking the screenings from the rack, a very black and septic sewage came down the sewer. The digester had a heavy scum mat upon it. In other words, the plant was badly neglected and looked it. We hope to be by again soon and want to be able to compliment the City and plant operator for a job well done.

A Feather in Our Hat. A highly complimentary reference to C.S.W.A., its members, and what it stands for was made by Col. Edward Fletcher of San Diego at the 1938 Spring Conference in that city.

Senator Fletcher, as the speaker of the evening said: "It has seldom been my pleasure to address such an outstandingly intelligent group of men, and I think I have never seen a gathering of men who were so intent and earnest in their technical meetings and general discussions."

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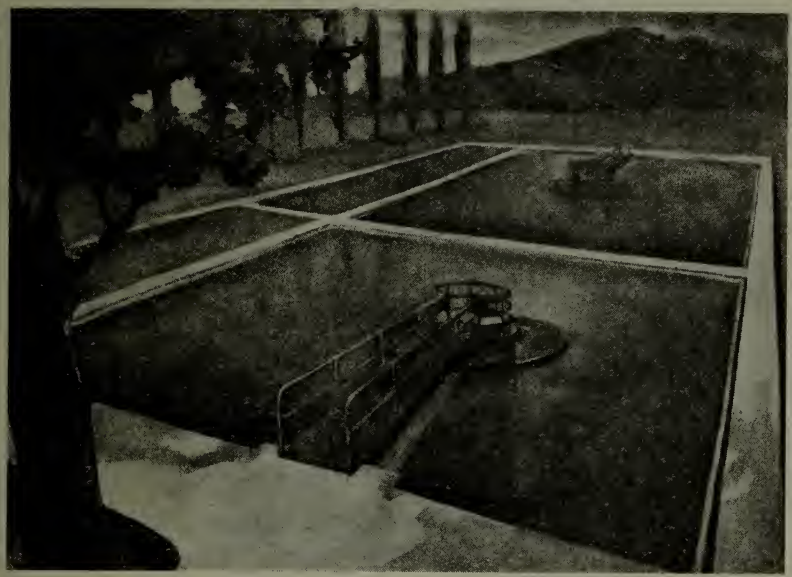
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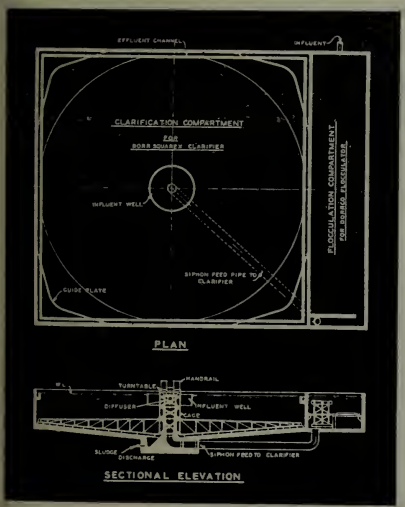
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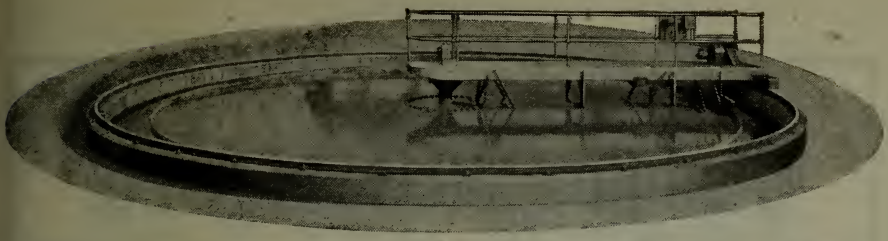
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CALIFORNIA SEWAGE WORKS JOURNAL

Official Publication of the California Sewage Works Association

Vol. XI :: 1939 :: No. 2

Minutes of the Eleventh Annual Spring Conference at Visalia California . . April 14-15, 1939

★

Sewage Treatment Plants in Vicinity of Visalia

★

Review of "Sewage and Trade Treatment"

★

Occupational Health Hazards in Sewage Disposal Plants

★

New Developments in Pipe For Sanitary Sewers

★

Observations of the Testing Laboratories of Europe

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ALEXANDER BELL 171 Second St., San Francisco

First Vice-President

H. G. SMITH 745 City Hall, Los Angeles

Second Vice-President

H. F. GRAY 2540 Benvenue, Berkeley

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R. R. RIBAL 701 City Hall, Oakland

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Vol. XI 1939 No. 2

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ELEVENTH ANNUAL SPRING CONFERENCE
VISALIA, CALIFORNIA
APRIL 14-15, 1939
PROGRAM

HEADQUARTERS HOTEL JOHNSON

Visalia, California

April 14-15, 1939

Thursday Evening, April 13, 1939.

7:30 P. M. Registration, Lobby Hotel Johnson

8:00 P. M. "PIPE AND PUBLIC WELFARE"
Sound Picture by U. S. Pipe and Foundry Co.
Banquet Room, Hotel Johnson.

Friday, April 14, 1939.

7:30 A. M. Directors Breakfast, Banquet Room, Hotel Johnson

8:00 A. M. Registration, Lobby Hotel Johnson

9:00 A. M. Business Meeting, Elks Club Room

10:00 A. M. New Sewage Treatment Plants in Visalia Vicinity
(a) Bakersfield—J. Holfelder, City Engineer
(b) Delano—Glen Johnson, Service Manager
(c) Visalia—N. A. Huth, City Engineer
(d) Wasco—Tipton Matthews, Water Supt. and Operator
(e) Tehachapi—C. S. Chitwood, Water Supt. and Operator; A. L. Madding, Asst. Water Supt. and Operator

12:00 Noon Luncheon, Elks Club Room
Address of Welcome—J. P. Gannon, Mayor of Visalia
Reply—Alexander Bell, President C. S. W. A.

2:00 P. M. Review of "Sewage and Trade Waste Treatment—H. J. N. Hodgson" by Charles Gilman Hyde, Professor Sanitary Engineering, University of California

3:00 P. M. "Occupational Health Hazards in Sewage Disposal Plants" by Dr. John P. Russell, Chief, Bureau of Industrial Hygiene, California State Department of Health

3:45 P. M. "New Developments in Pipe for Sanitary Sewers"
(a) Transite Pipe—J. H. Peterson, Staff Manager, Pacific Region Transite Pipe Department, Johns-Manville Corp.

(b) Unglazed Clay Pipe — H. W. Jewell, Engineer, Pacific Clay Products Company

(c) Asbestos Bonded Corrugated Pipe — L. W. Wyman, Chief Engineer, California Corrugated Culvert Co.

(d) Amercoat Concrete Pipe—Ernest F. Bent, Vice-President, American Concrete and Steel Pipe Company

7:00 P. M. Annual Banquet, Elks Club Room
Speaker: F. T. Letchfield—Asst. Vice-President, Consulting Engineer, Wells Fargo Bank, San Francisco, California
Subject: "Observations of the Testing Laboratories of Europe"

Saturday April 15, 1939

Caravan

8:30 A. M. Assemble Hotel Johnson
9:00 A. M. Inspect Visalia Treatment Plant
11:30 A. M. Inspect Delano Sewage Treatment Plant
12:30 P. M. Luncheon, Weit's Cottage Hotel, famous for Chicken dinners
2:30 P. M. Inspect Wasco Treatment Plant
3:15 P. M. Inspect Shafter Treatment Plant
4:25 P. M. Inspect Bakersfield Treatment Plant
Caravan will disband at Bakersfield

LADIES PROGRAM

Thursday Evening, April 13, 1939

7:30 P. M. Registration—Lobby Hotel Johnson
8:00 P. M. "Pipe and the Public Welfare"; Sound picture by U. S. Pipe and Foundry Co., Hotel Johnson

Friday, April 14, 1939

8:00 A. M. Registration—Lobby Hotel Johnson
9:00 A. M. Assemble Hotel Johnson for trip to Sequoia Park
12:00 Noon Luncheon among the Redwoods at Sequoia Park
5:00 P. M. Arrive at Hotel Johnson



ANNOUNCEMENT OF THE
TWELFTH ANNUAL FALL CONVENTION
CALIFORNIA SEWAGE WORKS ASSOCIATION

Oakland, California

September 18-19, 1939

✦

Monday, September 18, 1939

After the usual business meeting and election of Officers for 1940, the morning will be given to the presentation of two papers of unusual interest. Mr. Ben Benas, Superintendent of the Richmond-Sunset Sewage Disposal Plant in Golden Gate Park, San Francisco, will discuss operating problems and experimental results versus actual experience. Mr. Chas. H. Lee, Chief, Division of Water and Sanitation, Golden Gate International Exposition, will discuss the many problems of sewage disposal on a man made island having an extremely variable population.

The afternoon program will consist of a caravan to the San Francisco Marina Pumping Plant; Golden Gate Park Reclamation Plant and the Richmond-Sunset Sewage Disposal Plant.

Tuesday, September 19, 1939

The morning session will be held jointly with the Engineers' Section of the League of California Municipalities. Three papers will be presented dealing with the pollution of harbor and stream waters from the Federal, State, Sanitary Engineer, Treatment Plant Operator and Sportsman's viewpoints.

The afternoon will be California Sewage Works Association Day at the Golden Gate International Exposition.

SPECIAL

An operators' breakfast is being planned to take place at the same hour as the Directors' breakfast.

LADIES PROGRAM

The Ladies accompanying our delegates are invited to participate in the affairs planned by the League of California Municipalities.

ELEVENTH ANNUAL SPRING CONFERENCE
CALIFORNIA SEWAGE WORKS ASSOCIATION

Visalia, California **April 14-15, 1939**

MINUTES OF MEETING

Thursday, April 13, 1939

Thursday evening found many groups assembled in the Hotel Johnson lobby renewing old friendships. At 8:00 P. M. approximately sixty members and guests assembled to view a sound film telling the story of Cast Iron Pipe from its inception to its use in modern American cities, presented by U. S. Cast Iron Pipe and Foundry Company.

Friday, April 14, 1939

Business Meeting:

The Eleventh Annual Spring Conference of the California Sewage Works Association convened on Friday, April 14, 1939, at the hour of 9:30 A. M. in the Elk's Hall, Visalia, California, with President Alexander Bell presiding.

President Bell opened the meeting with a short message, saying that this Association was organized, prior to the first conference held in San Bernardino October 9-12, 1928, by a few men who visualized the importance of bringing before the public the necessity for sewage disposal plants, their proper operation and adequate maintenance to promote high sanitary standards for their community, and that by his message hoped to establish in the minds of municipal and state officials the true value of the Association as a technical and advisory board. This message is published in full elsewhere in this volume.

A call was then made for Committee reports:

Mr. Wm. Ingram, in the absence of Fred D. Bowlus, Chairman, reported for the Membership Committee, saying that the Committee had corresponded with the City Engineers of all cities having sewage treatment plants, urging that they and/or the plant operator join this Association; and expressed the hope of the Committee that the membership would reach a total of 300 by the Fall Convention.

Mr. John A. Clark, Chairman of the Publicity Committee, exhibited several clippings from local papers saying that two 450 and four 250 word articles appeared in the papers this morning and that others have been prepared to appear in Saturday morning papers of the Cities to be visited on the caravan. The assistance of Mr. Robert Van Etten, Educational Assistant of the Alameda County Mosquito Abatement District, in preparing the publicity campaign was acknowledged.

The above committee reports were written and are printed in full elsewhere in this Journal. The following committee reports were verbal:

Mr. A. M. Rawn, Chairman of the Legislative Committee gave a resume of some forty odd bills now before the Legislature appertaining to sewage disposal and his assurance that the Committee was carefully watching the interests of the Association. Particular reference was made to the Sewer Revenue measure with the prediction that it would become law at this session of the Legislature.

Mr. J. F. Smith, Chairman of Committee on Financing of the Journal, reported that while the advertising space sold for Volume 11 No. 1 of the Journal was a little shy of paying for the cost of publication, an attempt would be made to sell more space in Volume 11 No. 2 and thereby make up the small deficiency.

Mr. A. P. Banta, Chairman of Committee on Certification of and Schools for Operators, reported that preparations for the short course for Operators at the University of Southern California were well under way; that at the present date 108 operators had been certified and that three applications for certification were receiving the attention of the Committee. He stated that fundamentals and laboratory practice will be stressed at the school and that instruction will be under the able direction of Messrs. R. F. Goudey, Carl Wilson, H. O. Banks, Henry C. Meyers, Richard Pomeroy, D. W. Graham, C. F. Tennant, L. J. Alexander and A. M. Rawn.

Mr. Harold May, Chairman of the Committee on Award, stated that his committee was planning a campaign to create more than ordinary interest in the contest for the Award.

Mr. Richard Pomeroy, Chairman Fact Finding Committee, stated that his committee met the preceding evening, organized into groups, and that by the Fall Convention hoped to be able to report definite accomplishments.

Professor Leon B. Reynolds, Chairman on Revision of the Constitution and By-Laws, explained the several proposed changes, giving the reasons therefor, and in conclusion expressed his belief that a copy of the Revisions would reach each member in ample time for study before the Fall Convention.

Carl Beyer reported upon the Board of Control meeting held in New York City, January 20, 1939, as follows:

The publication of the 10th Anniversary volume—"Modern Sewage Disposal"—was announced. It is noteworthy that the introductory chapter was written by Prof. Charles Gilman Hyde and the chapter on ocean disposal of Sewage by A. K. Warren and A. M. Rawn, members of the C. S. W. A. The Editor in Chief, Mr. Langdon Pierce, and all those who assisted him, were given a vote of thanks. The volume is available to members at $2.50 per copy, $3.50 to others.

Approximately 2890 subscribers to the Sewage Works Journal were reported. It is to the credit of Business Manager Buffum that in spite of decreased advertising and increased printing cost, the Journal showed a small profit for 1938.

Membership in the Federation is now almost 2500. It was pointed out that the size of the Association is such that an undue burden is put upon the officers of the Association and upon the Chemical Foundation, whose personnel and office facilities have aided materially in the administration and

operation of the Association; and upon the Editor of the Journal. It is essential that ways and means be found to increase the income of the Federation, particularly if it is to grow and if its benefits and publications are to be maintained and improved. The advantages of the formation of a National Sewage Works Association similar to the A. W. W. A. were seriously discussed. A committee was appointed to investigate this entire subject and to report at an early date.

All officers were re-elected and committees reappointed to serve at least until the report of the committee mentioned above.

The Secretary-Treasurer reported that 208 members had paid 1939 dues to date, 61 were delinquent and that 16 new members joined since the first of the year. Though the financial condition of the Association is still good, reserves are gradually being diminished because of the increase in Federation dues and retention of Association dues. Increased printing costs of the Journal are also a factor. The financial statement in brief for the Association is as follows:

Balance as per bank statement	$454.68
Accounts receivable Advertising . . .	250.00
Total assets	$704.68
Outstanding debts	339.12
Balance as of date	$365.56

President Bell asked that all stand for a moment in silence in memory of Mr. Austin Burt, one of our most valued members who suffered a fatal heart attack soon after last Fall's Convention.

Mr. Albert L. Genter of Baltimore, member of the Maryland-Delaware, Water and Sewage Works Association, and Mr. Dario Travaini, City Engineer of Phoenix, member of the Arizona Sewage Works Association, were introduced by President Alexander Bell who extended to them the welcome of C. S. W. A.

Mr. A. D. Wilder, Director of Public Works, City of San Francisco, was introduced by Ben Benas and on recognition he signified his desire to become a member of the Association.

The following members were appointed to serve upon a Resolutions Committee for the Conference: H. F. Gray, Chairman—Leon B. Reynolds.

Technical Meeting:

The business meeting was adjourned at 10:15 A. M. and the technical session opened with the presentation of short papers on the sewage treatment plants at Bakersfield, Delano, Visalia, Wasco and Tehachapi by Messrs. J. Holfelder, Glen Johnson, N. A. Huth, Tipton Matthews and C. S. Chitwood, respectively. The papers were all read by the authors, except that Mr. C. C. Kennedy read Mr. Holfelder's paper and Mr. Ted Gregory read Mr. Tipton Matthews' paper. These papers revealed many interesting design problems, and operation experiences at relatively small sewage disposal plants.

The session was recessed at noon for luncheon which was held in the Elk's Club banquet room. A short address of welcome was given by Mayor

J. P. Gannon, to which President Bell replied expressing the appreciation of the Association for the gracious hospitality of the City and its officials. City Manager J. J. Philippe was introduced and he also offered freely of the facilities of the City. Professor Leon B. Reynolds read a humorous paper said to be the last will and testament of Alexander Bell on his retirement from office next September.

The meeting reconvened at 2:15 P. M. in the Elk's Club lodge room. President Bell announced that during the lunch hour he was informed of the sudden death of Mr. H. M. Ely, a most active member of the Association and member of the Award Committee, and asked that all stand in a moment of silence.

Dr. John P. Russell presented the first paper of the afternoon session on Occupational Health Hazards in Sewage Disposal Plants saying in part that while there were many health hazards in and around a sewage disposal plant their effects may be practically eliminated by reasonable precautions and avoidance of unnecessary exposure.

In reviewing H. J. N. Hodgson's report on "Sewage and Trade Wastes Treatment" Professor Charles Gilman Hyde in 6000 words gave a comprehensive outline of a book of 534 pages creating in many the desire to read the report in its entirety. Though Professor Hyde said no attempt was made to single out California practices, reference was made to several members in attendance and to the practices developed by them.

The third and concluding subject of the session "New Developments in Pipe for Sanitary Sewers" consisted of a group of four papers on Transite, Unglazed Clay, Asbestos Bonded Metal and Amercoat coated concrete pipes presented by J. H. Peterson, H. W. Jewell, L. W. Wyman and E. F. Bent, respectively. Unfortunately, time did not permit discussion of these papers which brought to attention recent developments in pipe for sanitary sewers.

President Bell called for a report of the Resolutions Committee. Mr. Gray read two resolutions, one in appreciation of the hospitality of our host City and the other of condolence to the family of H. M. Ely. The Secretary was directed to spread the resolutions upon the minutes and to send a copy to the City Clerk of Visalia and to the family of Mr. Ely, respectively.

The count of attendance at the above sessions was 95 to 100.

The meeting was adjourned at 5:15 P. M.

Ladies Program:

The ladies spent an enjoyable afternoon and luncheon at Sequoia National Park as guests of the City of Visalia.

Banquet:

The banquet was held in the Elk's Club banquet room with approximately 120 attending. Those seated at the head table were Mayor J. P. Gannon, City Manager J. J. Philippe, Francis T. Letchfield, the guest speaker, President Alexander Bell and Vice President H. G. Smith.

Mr. Letchfield, Consulting Engineer and Assistant Vice-President Wells Fargo Bank and Union Trust Co., San Francisco, gave an exceptional address published in full elsewhere in this Journal.

Saturday, April 14, 1939

Caravan:

Forty-five cars transporting about ninety members and their guests visited the sewage treatment plants at Visalia, Delano, Wasco, Shafter and Bakersfield. All of these plants are new or recently remodeled. The Bakersfield plant was under construction. Each of the plants presented one or more items of interest. At Visalia the old Imhoff tanks were converted into primary digestion tanks. The Delano plant is located in an alkali bed and while a few trees had been planted, gardening is most difficult. The Wasco plant for the most part is housed within a corrugated iron building located in the middle of cultivated fields and has the appearance of a well kept barn. At Shafter the operating parts of the plant are completely enclosed which presents a pleasing appearance. The construction work was well along at Bakersfield and here it was possible to see the procedure in the construction of Hewitt tanks.

The caravan disbanded at Bakersfield at 4:30 P. M.

Respectfully submitted,

R. R. Ribal,
Secretary-Treasurer

OBSERVATIONS OF THE TESTING LABORATORIES OF EUROPE

By F. T. Letchfield, Consulting Engineer and Assistant Vice President Wells Fargo Bank & Union Trust Co., San Francisco

Because the natural sciences are universal in their application one would imagine that scientific research would be the same the world over. And so it is, insofar as the scientist must deal with immutable physical laws. Strangely enough, however, a scientific research laboratory reflects the psychology of the country in which it is found and so, to that extent, may be used to gauge national habits. The conversion of scientific knowledge into things of everyday usefulness is the function of the engineer. It is his job to make things work in a practical way. Thus by observing the speed and the rate at which engineers translate scientific discoveries into industrial practices, within a given country, one may learn much of the long term economic outlook for that country. And so the inspection of scientific research laboratories in various parts of the world becomes something more than an interesting professional pastime if one will but look behind the scenes to the broader picture. However, before using such methods of analysis in respect to the present European industrial situation (as mirrored in its laboratories) I believe a word upon the subject of scientific research itself is advisable.

The late Dr. Michael Pupin defined scientific research as the process of listening to the language of nature. The more one ponders that definition the more profound it appears, for nature's laws in all their fullness have been complete, exact and exacting since time began. The first flash of lightning was an electrical discharge. The first object which fell to earth did so according to the law of gravitation eons before Newton wrote the formula

and bodies floated according to the principle of Archimedes like eons before that gentleman was born. Cosmic rays have been bombarding us throughout the ages and today nature is speaking to us in a language which would tell us all we wish or need to know if we could but understand it. But nature is a jealous guardian of her secrets, disclosing them only to those who have the patience to observe and the wit to interpret what they see and hear. Paradoxically, the more we learn the more illimitable appears the expanse of our remaining ignorance.

The methods the scientist uses are a queer mixture of inductive and deductive reasoning, arithmetical calculations and painstaking, persistent observations in which pure accident often plays a critical part. The apparatus he uses may be merely a sheet of paper or a vastly complicated device. It may be a mountain or an instrument so delicate it will react to the heat of a distant star. He uses balances so sensitive that one might tear from a cigarette paper a piece no larger than the end of a pencil and weigh it. One might write a small letter "i" upon it and weigh that,—then dot the "i" and weight that also. The scientist uses spectroscopes so finely made they will detect the presence of a given element even though it be but one part in a million. Electrical charges too small to be even suspected may be amplified to any desired volume or the hum of a mosquito be made loud enough to shake a building.

The motion picture one watches in a theatre is usually projected at twenty-four exposures a second; the slow motion shot of the golf expert or a football game has been taken at sixty-four exposures a second. But the scientist watches motions photographed at 5000, 10,000 or even 15,000 exposures a second and takes instantaneous pictures in less than one-hundred-thousandth part of a second. Thus he may, for five minutes or more, watch an incandescent bulb roll from a table and shatter upon the floor—or lengthen the time of explosion in an automobile engine to sixty seconds. By the use of neon gas and a mechanism called a stroboscope he may study the most rapidly moving part of any machine as though it were standing still—or make it appear to move forward slowly, or even backward. And one could continue for the balance of the afternoon recounting the strange things that are common, every-day sights in the modern scientific laboratory.

No less incredible is the arithmetical range over which the scientist roams. He may be using the Angstrom unit of light which is measured as one, two-hundred-fifty-four-millionth part of an inch, or he may be dealing in the speed of light greater than 186,000 miles a second. He may be examining temperatures at the sun finding them in excess of 6000° Centigrade more than twice as hot as anything we know on earth. Or again he may be reducing liquid helium to nearly 460° Fahrenheit below zero to a temperature but twenty-five-one-thousandths of one degree Centigrade above absolute zero, where he finds that his liquid helium conducts heat two hundred times faster than copper, that common table salt is as magnetic as iron filings, that a lead bell will ring like a piece of bronze and that a copper wire no larger than a match would carry all the power of Niagara.

The scientist may be measuring the electrical charge which holds the atom together, writing his answer in billionths or he may be studying the phenomena of his own, man-made lightning at ten, twelve or even twenty

million volts. He may weigh the earth in trillions of tons or he may ascertain the mass of the electron and write his answer by placing twenty-eight ciphers to the right of a decimal point, then the figure nine and then the word gram (some octillion octillionths of the smallest unit of weight), a particle so small that the people in this room could not count the electrons in a single drop of water though they spent a lifetime trying it. Yet the scientist has weighed it and measured its electrical charge, though he has never seen it.

I wish that time would permit telling of some of the miracles wrought by these modern alchemists. Of the production of alcohol from petroleum, of liquid gasoline from solid coal and solid rubber from acetylene gas, of silk from gunpowder, dynamite from corn, safety glass from natural gas and many, many other unbelievable transmutations. For while science is an exceedingly esoteric subject, its products affect our daily lives in a myriad of ways. The food we eat, the ceramic qualities of the dishes upon which it is served, the dyes that color our clothing, the lamps that light the room, the paint on the walls, the automobiles we ride in and the fuel to drive them. Every physical thing man has molded to his comfort and safety has benefited from science.

To study scientific progress in present day Europe a group of twenty-five engineers and scientists assembled by the National Research Council of New York, recently visited forty-six research laboratories covering eighteen different industries in England, France and Germany. As a member of that party I will endeavor to tell you, not so much in detail of what we saw as certain conclusions which might be drawn from what we observed. May I add, however, that it is quite impossible for any one traveling in Europe to return without a host of impressions all centering upon the marked differences in economic philosophies, social outlook and standards of living existing between America and those countries across the Atlantic. Nor can the fact that one may be totally unqualified to analyze or appraise them lessen their incidence upon one's reactions. Perhaps all the events of the past several years make one somewhat hypersensitive to international conditions at this time but in any event I would ask you to recognize that I express only my own personal opinions and that many of them fall far beyond the purview of engineering. Such lapses can only be excused perhaps as natural manifestations of an intellectual curiosity common to most human beings.

I can well imagine that any naturalized citizen would always have an especial reverence for the country of his birth and a genuine belief in its contribution to America. But any one visiting England for the first time, whose ancestry runs back a few generations in America, must conclude that England is truly our mother country; that we are essentially an Anglo-Saxon race despite the many heterogeneous racial alloys simmering in the melting pot. At least such were my own reactions which grew geometrically with our stay in England.

The mementoes one encounters of Queen Elizabeth, Sir Walter Raleigh, King George III and others, reminds one that the United States began as a group of Crown Colonies which were under British rule for one hundred and sixty-nine years,—a span greater than from 1776 to the present. And one realizes, too, that our political structures differ more in form than substance, that our laws have a common origin and that the ideals of the two

great nations are almost as identical as the language both use. I shall neve forget my feeling as I stood before a glass case in the British Museum an looked at the Magna Carta with King John's seal still attached for I rea ized I was looking at the birth certificate of political freedom and I knev that our own status would be vastly different had it not been for the battl on Runnymede Meadows over seven hundred years ago.

The definite feeling of kinship which grows as one revels in the historica riches of England accentuates the disappointment—one might almost say chagrin—which comes with the realization that physically, in an engineerin sense, England has hardly emerged from the Victorian Era. The process c disillusionment begins the moment one sets foot on English soil. It is evi dent in the wooden cars of the boat train, the ancient decrepit taxicab whic takes one from the station to the hotel, in the high percentage of obsolet equipment found in industrial plants, in outmoded methods and the old fash ioned design of many products. But looking deeper—for wooden cars, funn looking automobiles and 19th Century plumbing are but surface effects—on comes to the unescapable conclusion that England's backwardness is primaril due to the Englishman's religious regard for British tradition, with its con comitant of complacent satisfaction with things as they are. Such an outloo is lethal to engineering genius for the engineer must ride rough-shod ove tradition.

In the field of pure science England today—as in the past—is contribut ing a major share to the world's knowledge. We were privileged to spen one day at Trinity College, Cambridge. There we stood on veritable scien tific Holy Ground and almost felt the presence of Sir Isaac Newton, Faraday J. Clerk Maxwell, Cavendish and others who made Trinity the "Cradle o Science." There we were met in person by Sir Joseph J. Thomson, now th octogenarian Head Master of Trinity, who received the Nobel prize for hi discovery of the electron in 1897 and who, together with the Curies, is cred ited with inaugurating the present renaissance in physics. There, in hi capacity of Director of Cavendish Laboratories, we met the late and lovabl Lord Rutherford, who died but three months ago and who received the Nobe prize for his discovery of the neutron and other epochal contributions to th knowledge of atomic structures. There we also met Dr. Aston, anothe Nobel prize recipient, and found him at work in his laboratory weighin atoms. And there, too, we met Dr. Carmichael and Dr. Cockcroft, both inter nationally famous for their work in the field of cosmic rays and low tem peratures.

In many of the industrial laboratories we met men of exceptional ability particularly at the Metropolitan Vickers plant in Manchester, the Cotto Research Institute at Didsbury, at the laboratories of the great Brown-Firt plant in Sheffield and the Mond Nickel Company at Birmingham. The were doing excellent work, especially in the fields of textiles, low vacuun apparatus, the metallurgy of rustless steels and the hydrogenation of coal int gasoline and other hydro-carbon fuels.

Likewise the executive heads of these institutions were universally th fine, substantial, able Englishmen which the world, but particulary we Ameri cans, so admire. And so it was something of a shock to observe the ver

splendid abilities at the top and the definite mediocrity at the bottom of the industrial structure in England. Nor is it easy for the American to rationalize the great disparity between the standards of living for a considerable number in the upper social strata of England and the great masses at the bottom. The evidence of such a gulf made one question the widespread belief held here in America that England has solved her social and labor problems on a much more enlightened basis than have we. True there is greater stability between employer and employee and the English system may be adequate for England. But stability of employer-employee relationship does not necessarily mean progress for the worker. Far from it. As the status of the English laborer amply attests.

I must admit that we left England with mixed emotions for we saw a country which industrially is behind America at least a generation. We saw a country whose industry would be swamped over night by Japan's mechanized labor, Germany's engineering ingenuity and America's mass production, were Colonial Preference tariff walls and other artificial barriers once leveled. We found a country which is dropping farther and farther behind the rest of the world in all these things we call modernization.

On the other hand, no one, I believe, can visit the great offices of Lloyds in London, where the insurance threads of the world are knotted, or peruse the statements of Barclays, Midland or other such banks,—all having deposits of two-hundred to four-hundred-million pounds—or meet and talk with the heads of British Chemical companies, the enormous trading corporations or great shipping concerns without being convinced that London is still the financial and business center of the world.

Likewise one must inevitably be impressed with a certain quality, a substance, a something in the English character which defies appraisement. Call it what you will, my own belief is that it springs from their very love of tradition. For I believe that a pride in one's own country and an abiding faith in its basic institutions are prerequisites to the sterling citizenship so universal to the English.

And so as we crossed the channel to Calais the thought occurred to me that, could England but adopt more of America's industrial philosophy and if in our own country we might follow the English practice of basing our laws on proven experience rather than upon wishful thinking and theoretical experimentation,—both countries might be better off.

In France, our official host was the Under Secretary of State for Foreign Affairs, M. Jean Perrin—one of France's leading scientists and Nobel Prize men. M. Perrin told us that even though he is Chairman of a Government Committee for the Advancement of Science and Engineering in France, that he, himself, had never been allowed inside one French Industrial Research Laboratory or plant. One can well imagine then, that we, as foreigners, had to secure our information of French Industry deductively. However, there were many straws blowing in the wind, and straws quite often tell as complete and sometimes a more interesting story than the stack from which they come.

We were taken to many of the Governmental Laboratories, the Aviation Laboratories, the Locomotive testing stand at Vitry and the like,—also to

many colleges, universities and endowed institutions. Among others we visited the College de France, founded by Francois Lr. in 1530. It is historically important because it was here that science was first adopted as a subject for organized study. It is perhaps even more important as the birthplace of the Engineering profession.

We spent one memorable afternoon at the Pasteur Institute and one incident of his life and work is of more than passing interest to all Californians for, strange as it may seem, he affected the industrial history of the state in a peculiar way. In the early sixties the silk industry of France and Italy was nearly wiped out by an epidemic of pebrine, a plague fatal to silk worms. Conditions became so acute that it was profitable to raise silk worms in California and ship their eggs around the Horn to the Italian and French hatcheries. The infant industry flourished and grew for a period of eight or ten years and a considerable acreage in California was given over to the cultivation of mulberry trees. But Pasteur, when appealed to by the silk men of France, found a preventive for pebrine and the California industry died a sudden death.

We spent another unforgettable day at the Radium Institute where we had the honor and privilege of meeting Madame Joliot Curie, who is ably carrying on the work of her illustrious parents. Here I should like to digress for a moment to cite examples of the type of scientific accidents which so often change the course of human events.

Pierre and Marie Curie were not searching for a cure for cancer when in 1897 they discovered radium. They were endeavoring to identify emanations Becquerel had observed the year before coming from a Uranium compound. When radio-activity was found to consist of alpha rays, beta rays and gamma rays the use of radium in the treatment of cancer automatically suggested itself.

By some poetic justice Madame Joliot Curie one day in 1932 was observing actions transpiring in a Wilson Vacuum Chamber when another scientific accident happened. A photon struck an atom of aluminium and transmuted the latter into radioactive sodium. As a result there are today laboratories in France, England, Germany and America producing artificial radioactive salts with the thought that these can be induced directly into the blood stream where they will travel to the affected part, give up their emanations therapeutically and forever after remain harmless. Thus does the acuity of some scientist so often benefit mankind in strange unexpected ways.

It was difficult for us to understand Madame Curie's English but no one could miss her earnestness, professional zeal and intellectual integrity. In fact meeting and talking with such gigantic figures in the realm of science as Madame Curie, Lord Rutherford, Thomson, Aston and others, I have mentioned, one realized that one was standing in the presence of those whose names would live long, long after those of the Stallins, the Hitlers, the Mussolinis and other political figures of the day, will have been forgotten by all save a few students of history.

As a test of that premise, may I point out that there are but few in this room who do not know of Sir Isaac Newton and his work. But I wonder how many could tell who ruled in England during his lifetime.

France, like England, has contributed greatly to the field of pure science. The roster of the French Academy is studded with such names as Levossier, GayLussac, LeClanche, Pasteur and others. And today the halls of learning in France are manned by exceptionally able scientists. But the French scientist seems to be working in an intellectual vacuum. It is due primarily, I believe, to the Frenchman's conviction that Paris is the hub of the intellectual universe. As evidence of that belief one will find students from all over Europe, America and other parts of the world in French Colleges and schools but will find few Frenchmen studying in institutions of learning beyond the borders of France. Such intellectual inbreeding if one may be pardoned the expression, is a devitalizing influence tending to confine scientific progress to academic limits. For instance in France, the country which gave the world Pasteur, one still boils the milk as a sanitary precaution and regards all public water supplies with a jaundiced eye.

The French are good mechanics and have an extraordinary ability to put mundane materials together gracefully as symbolized by the beauty and symmetry of the Eiffel Tower. Likewise the French are good engineers and individually do much brilliant work but their collective genius is frustrated by a medieval industrial philosophy which still regards labor as a commodity to be purchased in the cheapest market, which still refuses to replace obsolete equipment, which still regards the purchase of a labor saving device as an unwarranted extravagance. It is no mere coincidence that while Renault was famous before Ford was heard of, yet where there is one French car in America there are one-thousand American automobiles in France. Bleriot sensed the modern airplane before Wright and Curtis, yet—compared to our modern transport planes the French ships of today look like galvanized iron sheds with wings attached.

All in all one is forced to the conclusion that France has much more to learn from America than it has to teach us. One does regret however, that those among us who believe that the high road to industrial greatness lies in the direction of legislative restrictions or coercion could not be compelled to visit France and observe at first-hand what happens to industry when it is placed in a legislative straitjacket, such as fashioned by M. Blum and his Front Populaire.

One evening about seven o'clock, we left Paris on the International train for Berlin. We crossed the German border about midnight and could tell that event, not by the Customs Guards for they came later, but by the roadbed for it was so much smoother and we had our first contact with the precise mental processes of the German Engineers.

About three in the morning two uniformed Customs Guards came into our compartment. They paid no attention to our bags but meticulously counted every penny of the money we had declared upon crossing the border and upon departing warned us we were to carry no newspapers into their country.

We arrived in Berlin the following morning where we had our preconceived ideas of the secrecy, political surveillance and espionage that would cover our movements knocked into a cocked hat by the very comprehensive program which had been prepared for us and the evident willingness of the

German Engineers and Scientists to give us all the information we could ask for.

Let me say at the outset, that it is impossible to secure an accurate picture of present day Germany from our domestic newspapers and, unfortunately, the longer one stays in Germany, the more one learns of it, the more confused one becomes because each set of facts are so contradictory. But perhaps a brief outline of what has happened in Germany may help to illuminate the current scene.

The Versailles Treaty stripped Germany of her army, her navy, her air force and her pride. In the political setup following the collapse of the monarchy no one party had a majority, yet each minority could—and did—make trouble. Hindenburg was universally beloved and respected but too old and too feeble to do more than keep the German ship of state afloat. Somewhat in desperation the bankers and industrialists backed Hitler, believing that with such men as Schacht, Luther and others at his side he could be guided and controlled. But the tail immediately wagged the dog in alarming fashion for Hitler, regardless of his many shortcomings, is a master of mass psychology. As such he tore open historical wounds of racial prejudices and hatreds and then proceeded to anoint them with a series of manifestoes and edicts which to us can seem nothing short of barbaric. But strangely enough, the German people regarded them as the only possible course.

Herr Hitler has torn up the Versailles Treaty, has given back to Germany her army, her navy, her air force and—more than all else— has restored the Germans' belief in themselves and their pride in their country. It is the latter which is responsible for Hitler's amazing popularity throughout the Vaterland. I was told, not by Germans but by those who, through long residence in the country, are competent to speak authoritatively, that a secret poll such as we have in America, would tomorrow give Hitler a majority of at least 75% on any personal issue.

He has succeeded in regimenting in all minutia the lives of sixty-five million people including seventy thousand highly trained scientists and engineers whose energies are mobilized and coordinated to an amazing degree upon a program of "Ersatz" ("Ersatz" meaning substitute). We did not visit one research laboratory in Germany which was not endeavoring to find some indigenous material or to produce some synthetic product as a substitute for something heretofore imported. Herr Hitler is determined that Germany is to be economically self-contained. It is of course a crazy and impossible economy, but out of it and because of its very impossibilities are coming many startling things. Developments which some day, when the miasma of Nazism has passed and the world has regained its sanity, will be felt commercially and economically in this country—unless in this country we, too, bend every energy to keep abreast. This I confidentially expect we shall do.

We saw wool made from the roots of beech trees—after turpentine and resin had been extracted as useful by-products. As a textile it has its shortcomings but it costs only half as much as animal wool in Germany. Most of the automobile tires now used in Germany are made from acetylene gas. The motor fuel is gasoline hydrogenated from brown coal, peat and mixed

with 20% potato alcohol. Aluminium, magnesium and many light-weight alloys are substituted for steel and iron wherever possible. Bakelite and a host of synthetic plastics are used in place of wood. Their requirements for ammonia and other nitrogenous derivatives are made from liquid air and coal gas. At the I. G. Farben plant in Ludwigshafen we saw synthetic sapphires, amethysts, emeralds, rubies, garnets and aqua marines that you and I couldn't tell from true gems.

But traveling through Germany with its inevitable human contacts and opportunities for observations one learns of other things beside the remarkable abilities of the German scientists. One learns for instance, that every Christian German boy or girl at the age of six, goes willy nilly into the Hitler Jugend. And there they stay until the age of ten when they go—not into the boy scouts or girl scouts—but into the Hitler Movement where every moment of their lives is accounted for until they are eighteen. Then the girls, regardless of what social strata they come from, spend six months in girls camps helping the farmer's wife with the children, or scrubbing floors or even raking hay in the field. And the boys—at the age of eighteen—do their six months' "Arbeit" in the labor battalions, draining swamps, making roads or building fortifications. Then they go into the army. That statement, however, is but an euphemism for every German boy and girl is "In the Army" from their sixth birthday on. And one wonders what thoughts must be seething in the minds of their parents whose early and formative education was had when German philosophy was one of the richest in all history.

Friends of ours—an American couple living in Berlin—took their two sons out of the German schools last year for they casually asked the younger —age 9—what he had been doing at school that day and he replied, "Oh, today, we practiced throwing hand grenades!" Further inquiry disclosed that he was proficient at stringing barbed wire and digging trenches and that the older boy—13—was having bayonet and rifle practice four times a week.

At Heidelberg one no longer sees multi-colored uniforms and caps of the student fraternities for they have been done away with as too individualistic. But the old dueling hall has just been refurnished and Hitler blessed it with an edict virtually making mandatory the settlement of certain types of disputes with the broadsword,—for bloodletting fits in nicely with Mr. Hitler's scheme of things.

I had expected to emerge from Germany in a belligerent frame of mind but I left with a feeling of pathos and tragedy for, on one hand, one sees in Germany evidences of splendid physical accomplishments in the reclamation of fifteen million acres of tide lands, the elimination of slums, a great new highway system, public buildings, splendid schools, laboratories and the like. But on the other hand one sees sixty-five million splendid people being led by a madman waving a sword at a mad world, attempting an impossible economy which is rapidly raising the cost of living, lowering the standards of living and generating social pressures which sooner or later will explode unless they be relieved or diverted by war. It is fear of this last which covers all Europe like a pall. To us here in America, due to our isolation and invulnerableness, the threats and rumors of war have certain unreal or

at least only academic qualities. But as one travels through Europe the menace of war, indeed its likelihood, becomes a grim reality.

On every hand one sees bodies of troops accoutered for action. Notices in public buildings of what to do and where to go in event of an air raid. Authorities in Berlin had measured the cellar of the home of some American friends living there, had assigned twenty-two people to occupy it in case of attack and had even left materials with which to caulk the windows and doors to keep out poison gas. Other friends in England were building a bomb-proof shelter and an acquaintance in France keeps a seagoing schooner in readiness at Marseilles.

And so, after the disappointments of England, the archaic and chaotic picture in France and the sinister tragic atmosphere of Germany, it is perhaps not surprising that as we set sail for home the query kept running through my mind, — "Why is it that America is preeminent among all nations?" To emphasize that preeminence may I paraphrase an editorial by Mr. Merle Thorpe which appeared in *Nation's Business* for April 1934.

> "With seven per cent of the world's people the United States has more purchasing power than all Europe combined. This little group has created and owns more than half the world's wealth. From six per cent of the world's acreage they harvest more than half the world's foodstuffs. Sixty per cent of the minerals are extracted in America. Half the communication facilities, nearly half the railways and electrical energy have been developed and are in use here. Individual transportation is triumphantly interpreted in the production of ninety-two per cent of the automobile output, which is operated on 600,000 miles of paved highways.
>
> "This seven per cent maintains a standard of living which consumes half the world's coffee, half of its tin, half of its rubber, one-fourth of its sugar, three-fourths of its silk, one-third of its coal, two-thirds of its crude petroleum.
>
> "In 1933 more than three billion dollars were spent on education, an amount that topped the total spent by all other countries. Nowhere are there such luxurious buildings, such a wealth of educational facilities. European schools enroll only a small percentage of the number of children attending American schools.
>
> "Real and practical independence for women; the 'old order' provided gainful occupations for 11,000,000 women, assimilating 7,000,000 since 1900.
>
> "The American Plan produced three times as much wealth as the whole world had been able to produce up to 1776, and distributed it so widely that the condition of the average man became a magnet to attract all other peoples. So voluminous was the response that the United States was forced to set up immigration barriers to prevent a flood of foreign nationals. What the common man was able to do for himself in this land of opportunity is eloquently suggested by the millions of depositors in savings banks and building and loan associations, by the 65,000,000 protected with life insur-

ance, by the 15,000,000 security holders, by the sixty per cent of farms unencumbered, and the fifty-five per cent of freeholders of urban homes."

But statistics alone are not the only evidence of the vitality and vigor of the American System. I have seen it personally in a Model "T" Ford negotiating the impassable roads of Siberia. I have seen it in modern service station equipment high in the Swiss Alps; in American cash registers and bookkeeping machines back of hotel desks in Germany and many familiar names of American concerns on manufacturing plants in England. I have seen it in the ubiquity of Singer Sewing Machines, Eastman Kodaks, Packard cars, Woolworth Stores and the like. One may see the same evidence in offices of the American Express Company in Paris or Rome or London or Geneva or any other place where tourists go for they are filled with American school teachers and "white collar" workers. Where else in all the world can salaried people, in large numbers, spend their vacations traveling the globe?

There are some who believe that America's unique economic status is due to our vast natural resources. But if that were the answer, then Russia would excell us. If it were due to a large, intelligent population, then China would lead the world. If it were because of the so-called "Capitalistic System" then France would have living standards approaching our own. If it were solely because of a democratic form of government, then the masses in England would be far better off. If it were the result of engineering skill or scientific knowledge, then Germany would crowd us for first place as a producer and consumer of the world's goods. All such premises leave the riddle still unsolved. I presume every one will have their own answer and I am perhaps too chauvinistic to speak without prejudice, but to me America's greatness springs primarily from three factors: First, the age old struggle for freedom found a soil here in America in which it could blossom and flourish. Second, the qualities of self-reliance, resourcefulness and courage required in the struggle to conquer our physical frontiers, became dominant, national traits. The third factor—which after a trip through Europe I believe is the most imponderable of all—is really a product of the first two. I refer to the sovereignty of the individual, the equality of rights, without hereditary or arbitrary privileges and rights not vouchsafed to all. In short, the absence of caste or of traditions which still impose the psychology of caste. I may be laying undue stress upon the latter but it is the only premise by which I can rationalize the great difference between what we saw in Europe and what I know of America.

And so, if you were to ask me what thought above all others stands out in my mind as a result of visiting the scientific research laboratories of Europe I should have to tell you frankly that it falls far afield from the miracles and wonders of science, from the things of historical interest, from the beauties of Old World art galleries or the pleasures of travel in general. I should have to admit that the thought which supersedes all others and which grows with each retrospection, is a formless prayer of thankfulness that a kind destiny has given me citizenship here—in America.

RESOLUTIONS

To: *The Family of Mr. H. M. Ely* April 14, 1939
Ontario, California.

Whereas, Mr. H. M. Ely has this year suddenly died to our regret and great loss, and

Whereas, he has for many years been a member of the California Sewage Works Association, active in our affairs, interested in our progress and known and liked by all of us, now, therefore

Be It Resolved, by the California Sewage Works Association in Conference assembled at Visalia, California, on April 14, 1939, that we regret most deeply the untimely passing of this valued member of our Association; that a copy of this Resolution be spread upon the records of this meeting, and a copy thereof, duly engrossed, be presented to his family.

To: *The City Clerk* April 14, 1939
Visalia, Calif.

Be it Resolved, by the California Sewage Works Association in Conference assembled at Visalia, California, April 14, 1939, that we extend our thanks and appreciation to Mayor J. P. Gannon, the City Council and the City Manager for their courtesies and considerations in making this Conference most successful and enjoyable; to the Police Department thereof for forebearance in relation to infraction of local ordinances; to the Local Arrangements Committee for the excellent program and fine facilities provided; and to the Ladies Committee for their very fine entertainment for our ladies.

Resolutions Committee
H. F. Gray, *Chairman*
Leon B. Reynolds

H. M. ELY

On March 24, 1939, following a heart attack, death claimed Mr. H. M. Ely, Chief Operator of the Ontario Sewage Treatment Plant since its construction in 1935. Under Mr. Ely's operation the Ontario Plant won the Award Plaque for 1938 presented by California Sewage Works Association. In his death the City of Ontario lost a loyal and efficient worker and we have lost a true friend.

PRESIDENT ALEXANDER BELL'S OPENING ADDRESS

ELEVENTH ANNUAL CONFERENCE

California Sewage Works Association Meeting

Visalia, California . . . April 14, 1939

While I have attended practically every meeting of the California Sewage Works Association since its inception, this is my first meeting as President of the Association and I feel that I am privileged in taking a few minutes from the time allotted to our business meeting to express my appreciation of the honor which has been conferred upon me and to review with you some of the thoughts which have crossed my mind in thinking of the California Sewage Works Association.

It is well to remember that this organization has grown from the inspiration of a few men, interested in public health and general betterment of sewage disposal practice, the maiden meeting being held in San Bernardino October 9-12, 1928. These men and their successors deserve great credit for so completely organizing the Association and then developing it as an outstanding group of its type.

These men visualized the need for some organization through which operators, technicians and engineers could exchange their thoughts, observations and reports of experience in common meetings and publications. Organizations, like individuals, rise on stepping stones of their past selves to higher things. So long as we adhere to the ideals of the founders, are willing to accept more responsibility for furthering the public good, and so long as we subordinate all interests, personal or class, to the achievement of that end, the California Sewage Works Association will survive and its members will enjoy the great pleasure that comes from doing good.

There is every indication that the Association is organized to a point where it is our duty to assume a public responsibility. Serious consideration should be given to the establishment of a workable mechanism as related to sewage plant operation, sewage plant maintenance and sewage plant design. What I have in mind is a contribution of public service by the Association to municipalities who see fit to seek its advice along these lines.

We are faced with many opportunities for making the world a better place in which to live and for furthering the ideal of "the greatest good for the greatest number." We can grasp these opportunities by formulating a rational program in which this group agrees on dedication of its energies and direction of its activities toward education of municipal and industrial executives and dissemination of fundamental information regarding accepted principles of waste treatment.

We have ample justification for giving just publicity to results of individual efforts of municipal employees working in our branch of public health activity. By concerted action, the California Sewage Works Association can draw attention to the value and importance of higher sanitary standards.

This program is suggested as the step preliminary to full acceptance of our duty as employees of commercial, industrial, technical and municipal organizations. The program is suggested as one route for major progress forward in showing the California Sewage Works Association stands for something real in the public health field and, more important, that its work is authoritative as to quality and that it is dedicated to the work of establishing the proper guide posts in order to direct development of sewage treatment for the greatest public good.

It is the duty of each of us to aid in the solution of waste disposal problems; to aid by loyalty and good faith, to aid by intelligent study and well considered judgment; to avoid intemperate and disloyal criticism; to abstain from those reckless charges of bad faith and those ill-judged condemnations which render difficult the highest form of concerted effort by our organization.

The men charged with official responsibilities in this organization are only human and, no doubt, have made and will make errors, but the splendid achievement over a long line of leaders should continue to inspire the confidence of our members.

REPORT OF PUBLICITY COMMITTEE

Your publicity committee has not had an opportunity to have a formal meeting as yet. However, we shall get together at some time during this conference to discuss and formulate some plans we have in mind for publicizing our organization, both before the general public and to our associates that are not now members of the organization.

We have been examining the map which Mr. Ben Benas prepared for this Committee last year, and are amazed to see how many communities in California, having some form of sewage treatment, have no name on our membership roster. To us, this is a place for the efforts of the publicity committee and the membership committee. We have in mind some joint action by these committees, directed at these communities and their governing heads, which will inform them of the aims and functions of our organization, and urge the communities and their employees engaged in this field to join the Association.

We have endeavored to publicize this conference in the local papers and in the papers of the towns which we shall visit tomorrow. In this effort, we were greatly assisted by Mr. Robert Van Etten, Educational Assistant of the Alameda County Mosquito Abatement District. With his assistance we prepared "copy" for the morning and evening Visalia papers; also the Delano, Wasco, Shafter and Bakersfield papers, for release, last evening, and this morning in Visalia, and today in the other papers. I hope to be able to report that these two—450, and four—250, word articles were published.

Notices of the conference were sent to "Water Works and Sewerage," "Municipal Sanitation," "Western Construction News," "Western City," and "Engineering News Record."

We shall also send reports of the meetings of this conference to them for publication.

Plans for publicizing our fall meeting with the League of Municipalities in Oakland will be discussed by our Committee during this conference.

Respectfully submitted,

HERBERT FOSTER, JR.
FRED MIICK
PAUL SHAW
JOHN A. CLARK, *Chairman*

REPORT OF MEMBERSHIP COMMITTEE:

The work of the Membership Committee has been more or less routine since last Fall. Notices were sent out on December 15, 1938, to all members asking for payment of 1939 dues. To date the response has been very gratifying, and we now have more than 200 paid members. This is a larger number than any previous year at the same time.

About a month ago approximately 100 circular letters were sent to all City Engineers throughout California who were not members of C. S. W. A. These men represent cities where some form of sewerage system and treatment plant exists. Subsequent to this notice, each man on the Membership Committee was given a list and a request was made to use as much influence as possible to get the City Engineers whom they knew or who reside in their part of the State to join the Association.

I wish to express appreciation for the valuable services of the members of the Membership Committee, especially the work of W. T. Ingram.

I have recently received from Mr. Gillespie a roster of Sewage Plant Superintendents in California. It is hoped that many of these may be induced to join the Association during the current year. We fully expect to have a paid membership of at least 300 by the time of the annual Fall meeting.

I am making a personal appeal to the City Engineers at their conference in Bakersfield on April 13.

FRED D. BOWLUS.

ROSTER OF ATTENDANCE

ELEVENTH ANNUAL SPRING CONFERENCE

CALIFORNIA SEWAGE WORKS ASSOCIATION

VISALIA, CALIF. -:- APRIL 14-15, 1939

Name	*Residence*
John A. Clark	San Francisco
Harold S. May	Palo Alto
Mrs. Harold S. May	Palo Alto
Mr. & Mrs. Jack H. Kimball	Palo Alto
Elbridge G. Studley	Los Angeles
Carl M. Hoskinson	Sacramento
Frank C. Horton	Los Angeles
G. C. Parkes	Los Angeles
Richard Pomeroy	Harbor City
S. A. Hargood	San Bernardino
Mrs. J. P. Gannon	Visalia
J P. Gannon	Visalia
Wm. F. Berg	San Bernardino
Mrs. C. M. Burnett	Visalia
Bea R. Hammer	Visalia
H. B. Foster, Jr.	Berkeley
A. C. Beyer	San Francisco
A. M. Rawn	Los Angeles
Carl Tennant	Los Angeles
J. H. Peterson	San Francisco
S. Johnson	Delano
Geo. Haddican	Delano
Leon B. Reynolds	Palo Alto
A. T. Wintersgill	Los Angeles
David Currie	San Gabriel
Mrs. Chas. Hammer	Visalia
A. A. Taylor	Signal Hill
Jno. B. Gill	San Francisco
John C. Lane	San Francisco
Mrs. W. R. Updegraff	Los Angeles
Mrs. J. H. Peterson	San Francisco
H. A. Knoedler	San Francisco
Ray W. Murray	Sacramento
W. F. Foster	Los Angeles
Bradley W. Wyatt	San Francisco
J. C. Albers	Glendale
A. L. Genter	Baltimore, Md.
Alexander Bell	San Francisco
Harry Goodridge	Berkeley
G. T. Luippold	Los Angeles
B. Benas	San Francisco
H. D. Wilder	San Francisco
E. A. Reinke	Berkeley
A. L. Frick, Jr.	Los Angeles
J. S. Gallagher	San Francisco
Frank Currie	San Bernardino
Mrs. Frank Currie	San Bernardino
Mrs. Norman Huth	Visalia
N. A. Huth	Visalia
J. J. Philippe	Visalia
Mrs. J. J. Philippe	Visalia
J. F. Smith	San Francisco
Lawrence H. Cook	Menlo Park
Grover L. Walters	Fullerton
Mrs. Grover L. Walters	Fullerton
Bob Walters	Fullerton
Fred J. Klaus	Sacramento
A. C. Mellinger	Auburn
H. H. White	Auburn
Robt. Moyer	Auburn
R. E. Mittelstadt	Sacramento
D. R. Kennedy	Long Beach
Charles Gilman Hyde	Berkeley
Ada R. Batty (Mrs. Fred)	Los Angeles
Fred A. Batty	Los Angeles
Mrs. A. B. Shearer	San Anselmo
Mrs. J. F. Smith	San Francisco
Wm. J. O'Connell, Jr.	San Francisco
D. Travaini	Phoenix, Ariz.
R. F. Goudey	Los Angeles
F. W. Jones	Stockton
H. W. Jewell	Los Angeles
Mrs. Lawrence H. Cook	Menlo Park
Mrs. L. B. Reynolds	Palo Alto
Phil L. Mauldin	Los Angeles
J. H. Van Norman	Los Angeles
S. A. Kerr	Inglewood
T. C. Wilson	Los Angeles
F. R. Galloway	Los Angeles
Geo. L. Wood	Bishop
R. E. Ramseier	Hayward
Mrs. R. E. Ramseier	Hayward
A. B. Shearer	San Anselmo
Harry B. Ogle	Chico
J. L. McBride	Santa Ana
Harold Shawl	Visalia
Mrs. Raymond Ribal	Oakland
Raymond R. Ribal	Oakland
C. T. Faw	Oakland
Mr. & Mrs. C. C. Kennedy	San Francisco
W. T. Knowlton	Los Angeles
John Skinner	Glendale
Winston R. Updegraff	Los Angeles
T. W. McKey	Los Angeles
G. Kjellburg	Riverside
R. D. Woodward	Laguna Beach
William T. Ingram	Stockton
G. C. Clark	Huntington Beach
Mrs. Alexander Bell	San Francisco
Mrs. H. G. Smith	Los Angeles

Name	*Residence*	*Name*	*Residence*
B. D. Phelps	San Diego	Albert Castro	Santa Clara
Harold G. Smith	Los Angeles	E. E. Frisby	Santa Ana
E. R. Waggoner	Los Angeles	Harold F. Gray	Berkeley
G. C. Zuckweiler	San Diego	Henry C. Peirson	Los Angeles
S. L. Lowry	Santa Ana	Mrs. Henry C. Peirson	Los Angeles
Adolf H. Koebig, Jr.	Los Angeles	H. J. Ongerth	Berkeley
Vernes C. Johnson	Covina	C. G. Gillespie	Berkeley
C. S. Chitwood	Tehachapi	A. Ackerman	Delano
Ted Gregory	Covina		

TEHACHAPI SEWAGE TREATMENT PLANT

By **C. S. Chitwood**
Operator Sewage Plant, Tehachapi, Calif.

Tehachapi is located in the mountains of Kern County at an elevation of 4000 feet and has a population of 1000 inhabitants. It is one of the oldest settlements in the State of California.

In January 1937 the city engaged the firm of Koebig & Koebig, Consulting Engineers, 458 South Spring Street, Los Angeles, to prepare a report on the proposed Sanitary Sewer System and Disposal Plant which report was used as a basis for submitting the question of bond issue for $31,000.00 to the electors. The election held in February, 1937, carried by the overwhelming majority of 10 to 1 which indicated the wholehearted support of the citizens in this worthy project. Following this the Engineers prepared and submitted to the Federal Emergency Administration of Public Works an application for Grant of $25,363.00 which was approved during the early Fall of 1937.

The contract for construction of system and plant was awarded in November 1937 and construction started almost immediately. Project was completed and ready for operation in May 1938. The construction was carried on successfully and without excessive delay although there were many days during the winter period when snow covered the ground and prevented steady work.

The plant site of 10 acres situated about one mile from town was donated to the city by one of the substantial taxpayers. All sewage is collected and carried to the plant and through the plant by gravity. Treatment of sewage is by a modified Imhoff Tank, intermittant trickling filter with the effluent being lagooned onto the 10-acre tract before it is percolated into Tehachapi Creek.

The plant is designed for a population of 2500 and a flow of 150,000 gallons per day. The Imhoff tank is 22 feet wide and 28 feet long, having a sedimentation capacity of 1728 cubic feet, above the sloping partitions, and a sludge storage capacity of 3747 cubic feet, sufficient for six months. The rotary trickling filter is designed for 1800 population, is 66 feet in diameter, rock depth of 6 feet.

The sewage is entirely domestic with little variation in quality throughout the year except for temperature variations. At present time there are 280 connections to the sewer system. The seasonal temperatures vary from about 100° in summer to freezing in winter.

Suspended solids on raw sewage vary from 200 to 250 parts per million and B O D from 200 to 250 parts per million. A detention period of about 2.06 hours is provided in the longitudinal settling tank, the efficiency of settling being as high as 60% at normal flows. A northerly wind keeps the scum drawn to the scum chambers on the effluent side of the tank thereby eliminating unsightly scum conditions. The gas deflector prevents the majority of the digesting sludge rising to the surface from entering the main settling compartment with the absence of the usual discoloration and odors of Imhoff Tanks.

Although the B O D reduction is not as high at the Imhoff tank as the suspended solids removal the greatest load of solids is removed for efficient filtration treatment.

The filter is dosed intermittently and by providing an ample capacity of air in the features of design all septic conditions have been eliminated in the filter furnishing an effluent crystal clear, of slightly musty odor and with some filter sludge deposit. The only life visible to the eye outside of a thin top coating of bacterial slimes are a few filter flies and small larvae discharged from the filter. The average B O D of the filter effluent is 70 parts per million and suspended solids also 70 parts per million.

One of the worst operating difficulties is the freezing temperature which is hard on the little outside equipment at the plant. During the one winter in service the concrete stood up very well. The sludge that has been drawn from the bottom of the Imhoff tank has reached a good stage of digestion for this type of installation. No septic odors have been prevalent in the sludge drawn off and the dried sludge has no noticeable odor.

The location of the plant and the natural topography of the country afford an entirely gravity system with no mechanical equipment necessary. No odors are noticeable on account of the excellent wind conditions.

The tanks are so designed that they have ample capacity for present and future population. There is no industrial waste to be provided for and no anticipation of any in the future.

Samples of sewage and sludge taken on March 25, 1939, at 10:00 A. M. showed the following results:

	Raw Sewage	Effluent from Imhoff Tank	Filter Effluent
Temperature	58°	56°	56°
pH	7.7	7.5	7.5
Suspended Solids p. p. m.	210	85	70
B.O.D. p. p. m.	220	170	70
Pct. Reduction susp. solids		60	67
Pct. Reduction B.O.D.		33	68

These were catch samples only. No offensive odor to filter effluent.

The plant practically operates itself but like all plants needs attention.

Since this improvement has been completed the City has shown considerable growth and is fast becoming a trading center for surrounding territory. Likewise by reason of the favorable climate in the summer time and the altitude, many people are making this locality their summer home and resort.

WASCO TREATMENT PLANT

By **Tipton Matthews**
Water Superintendent and Operator

The Wasco Public Utility District situated in Kern County was created in 1925 and a water system built immediately following the formation of the District. In the year 1936 it was thought advisable for the District, on account of the industrial wastes from the Creamery and the trouble the Creamery was having with the disposal of same, to build a sewer system.

It was impossible for the District to raise sufficient monies to build said system and disposal plant unless they could get Federal aid. A preliminary study was made and it was found that a bond issue for $90,000 could perhaps be passed and a grant of $61,363 could be obtained from the Federal Emergency Administration of Public Works. The bond issue was voted in August 1936 and in October 1936 the District retained the firm of Koebig & Koebig, Consulting Engineers, 458 South Spring St., Los Angeles, to design and supervise the construction of a sewer system and sewage disposal plant for the District.

A permit was obtained from the State Board of Health early in December, 1936, for sewage treatment to consist of sedimentation, separate sludge digestion, burning of sludge gas and chlorination for odor control, the effluent to be disposed of by broad irrigation over a 40 acre Tract in the SE¼ of the NE¼ of Section 9, T 27 S, R 24 E, M.D.B.&M. Kern County, which tract lies three miles from the business center of the District.

The plant was designed for domestic population of 1500 plus trade waste equivalent to domestic population of 4500. The maximum design flow is .6 million gallons per day.

The raw sewage, after coarse bar screening, enters the wet well from which it is pumped to a clarifier using Dorr mechanism with central feed, 35′ diameter and 8′ side wall depth. At the maximum flow a detention period of 2.30 hours is given in this unit. Surface floating material is removed by continuous scum skimmer.

The clarifier effluent following chlorination is disposed of by surface irrigation on the 40-acre tract with no nuisance created by odors. The effluent has built up the land from very sandy soil without much humous to where it is now raising good crops.

The sludge and scum are removed from the clarifier and pumped to the multdigestion system having Dorr domes and Dorr mixing equipment. The primary and secondary digesters are arranged in series each of 20′ diameter and 20′ side depth, to provide digestion allowance of 2 cubic feet per capita based on a total estimated population equivalent. The primary digester has a rapid stirrer and both tanks are covered, the secondary tank having a gas holder and designed for the return of the supernatant liquor back to the wet well.

The plant was put into operation in August 1937 and was turned over

to me to operate a short time afterward. Then the fun started. It was my first experience in handling a plant of this kind and I thought I had learned everything from the engineers, so depended on the instruction books that were left by the equipment Companies. However, I found everything in the books but what I wanted to know. I prayed a little, scratched my head and went to work in earnest to keep things going. It was like Christmas with a stream of gifts, neckties, silk socks, toothbrushes and other articles too varied and too numerous to mention.

I could not understand why the Engineers had put a bar screen in front of the wet well which did not operate automatically but it did not take me long to find out the logic of that because if I did not go down to clean out the darned screen I would not go near the plant and I make it a habit now to visit the plant twice daily, 5:00 A. M. and between 2:00 and 4:00 P. M. to clean off the screens, burn off the gas at the same time and pump sludge about 35 minutes. After pumping agitate one hour.

A peculiar thing has happened on the paint job. After operating about three months finger prints that were made during time of construction were noticed coming through the paint on the roof rafters of the pump house and in inspection of the plant you will see they are very apparent.

So far we have not experienced any trouble and it has been a pleasure to operate the plant. The only time the plant throws off any odors to speak of is when I pump the sludge from the clarifier. 700 cubic feet per minute of air is pumped by electric fan automatically when the pumps turn on or turn off, when the doors of the pump house are opened, and when the lights are turned on, which seems to relieve the odors in the plant to such an extent that I have not yet found it necessary to chlorinate.

The residue in the secondary digester is drawn off about once a month into sludge beds where it remains until dry and ready to be used for fertilizer. At present we have an offer from a Bakersfield concern for the purchase of the sludge for fertilizer. It was about thirty days after the first connections were made that sludge began to appear at the plant. At present we have 560 connections to said sewer system.

As potato raising is one of Wasco's largest industries we have 14 washers. These washers when operating use 450 gallons of water per minute. Each washer washes about one carload of potatoes per hour which gives quite an increase of sludge at the plant, mostly potato skins and some soil. The mud is the only thing that must be watched closely as it settles to the bottom of the tanks and makes the sludge heavy and hard to draw off. In that case we draw off sludge more often and that takes care of the potato problem.

When the plant was first put into operation there were only three washers and an Ordinance was passed that all potato washers should build a sufficiently large settling tank to settle out all mud so it would not get into the sewer. I guess I have been a little lax in enforcing that ordinance.

Tests were taken at the plant at 3:00 P. M. Saturday afternoon, March

25th, immediately following sludge pumping and the results are as follows:

	Raw Sewage	*Primary Effluent*
Temperature °F	69°	69°
pH	6.9	7.0
Suspended Solids P.P.M.	150	135
Pct. reduction-susp. solids		10
B.O.D. — p.p.m.	240	200
Pct. reduction B.O.D.		16

Overflow—Primary sludge digester—
Pct. moisture 98.4 Pct. volatile matter 65.9
Digested sludge—Secondary digester—
Pct. moisture 85.0 Pct. volatile matter 52.4

These are the first tests taken since the plant was put in operation. Normally a good effluent is produced. The reason for the effluent being so high in B.O.D. and suspended solids is that when the samples were taken I had just finished pumping sludge from the clarifier to the digester.

Since the design of the plant the population of Wasco has increased from 1500 to 3800. An area of one and one-half sections of land comprises the Wasco Public Utility District.

From my experience in the operation of the plant I do not see how said plant could be improved upon if given proper attention. So far it has been trouble free and I have no trouble at all in its operation. The water that leaves the plant is used for farming purposes on the 40-acre tract where the plant is situated.

SEWAGE TREATMENT AT VISALIA

By **Norman A Huth**
City Engineer

The Visalia Disposal Plant consists of separate sludge digestion and trickling filters without secondary clarification or any means of sterilization.

This type of treatment was decided upon after a careful study of the old plant and of the existing conditions, both surrounding the sewer farm and within the City. The City owns a sewer farm consisting of 160 acres located approximately three miles west of the town, which at one time was quite isolated; but during the past several years a considerable number of homes have been constructed in this area. Also one of the state highway laterals was built along the north boundary line of the farm since its purchase. It was therefore decided that the design of the new plant should eliminate, as far as was practicable, all possible nuisances. The old plant consisted of an Imhoff tank with auxiliary sludge storage capacity, inadequate sludge drying bed and depending upon broad irrigation for disposal of the effluent. This plant was considerably overloaded, especially during canning seasons. Precisable settling occurred during periods of overloading. The uncovered tanks and gas vent areas were a source of fly and odor nuisance. The ponding of unstable effluent used for irrigation purposes was another source of bad odors.

The City of Visalia is essentially a residential City. It has experienced

a steady growth in population of from 4550 in 1910 to 7263 in 1930, the present population being estimated in excess of 10,000. The only additional territory which probably will be annexed to the City has a total area of 160 acres with an estimated population of 2000. There are approximately 40 miles of sewer mains, a considerable portion of which is below ground water levels or adjacent to creek channels, and, of course, subject to infiltration. Sewer gaugings taken over a period of 16 days show an average flow of 1,600,000 gallons per day, with a maximum hourly flow at the rate of 2.6 million gallons per day and a minimum of 750,000 gallons per day. It was estimated that of this amount at least 500,000 gallons per day was infiltration. The water supply for the City is not municipally owned and is not metered. The per capita water consumption exclusive of infiltration is estimated at 120 gallons per day. Chemically the water is normal, with a comparative low in sulfates.

The biggest problem from a sewage treatment standpoint, however, are the Visalia Packing Company and Knudsen Creamery. The 1937 pack of the Visalia Packing Company consisted of approximately 6700 tons of peaches, 200 tons of apricots, 500 tons of nectarines and 900 tons of spinach. The Creamery has a capacity of 80,000 pounds of milk per day.

In 1930 a report prepared by Mr. A. E. Reinke of the California State Board of Health presented a picture which was definitely not optimistic as far as the disposal of the packing house wastes were concerned. Quoting from his report:

"Peach canning wastes entering the sewer cause a layer of peaches and peach fuzz to collect on the settling compartments of the Imhoff tanks, which if not skimmed daily, causes considerable fly and odor nuisances." This information together with our own experiences and the records of experiences of plants in other cities, attempting to treat this peach waste, was definite warning that trouble would be encountered unless adequate facilities were provided for skimming and digestion of this waste. It was for this reason that skimming was installed in the primary clarifier, also scum stirring in the heated digestion tank.

Investigation showed the cannery flow to be approximately .58 M. G. D. and the population equivalent of this flow would be 3000 persons.

The products of the Knudsen Creamery are cheese, butter and cream. It is estimated that the wastes of the creamery are between 30,000 and 40,000 gallons per day and are equivalent to approximately 1,000 people.

Based on the above data, this plant is designed for a future average flow of 3.12 million gallons per day and a population equivalent of 20,000. From weir gaugings it was determined that the maximum hourly flow would exceed the average by 60%.

A careful estimate made by the Consulting Engineers showed that incorporating the old Imhoff tanks into the new design would effect a saving to the City of $12,300.00 and would produce just as modern and useable settling and digestion tanks as the construction of entirely new ones. However, due to the peach wastes it was felt that additional digestion capacity should be provided for, hence, the additional heated digester was added.

The designing engineers considered two types of treatment as being

suitable for meeting the above conditions: i.e., activated sludge and trickling filters. The original construction costs would have been slightly greated in the activated sludge plant and the maintenance costs would have been at least twice as great as for the trickling filter type of plant. The main reason, however, for deciding in favor of the trickling filter plant as constructed instead of activated sludge type was because of the high percentage of industrial wastes during the canning season and the probable difficulties that would have been encountered thereby.

As to plant capacities the primary clarifier will provide a detention period of 65 minutes for the future maximum hourly flow. The digestion capacity is 3.15 cu. ft. per capita. The trickling filter will be dosed at the rate of 4.35 million gallons per acre per day. However, since this is a continuous and not an intermittent dosage, the load on the filter will amount to approximately 2800 people per acre foot. The sludge drying beds have an area of .8 of a square foot per capita.

The primary clarifier is equipped with Link-Belt "Straight-line" clarifying equipment and Currie air skimmers. The equipment in the heat digesters as well as the sewage distributors were furnished by the Dorr Company. The pumps pumping the sewage from the primary clarifier to the distributor were furnished by the Kimball-Krogh Company and are driven by an Enterprise gas engine and a Sterling "Speed-trol" electric motor, respectively. The float control of each is so designed that continuous pumping, proportioned to the in-flow, is assured. The electrically driven pump is so designed as to act as a stand-by for the engine-drive pump. Measurement of the sewage flow is determined and recorded by a Morey-Jones electric flow meter, operated from a Venturi tube in the pump line. Sludge is pumped by a Carter sludge pump. The piping for all sludge pumping is brought to a control manifold where by proper valving, sludge may be pumped from the primary clarifier to the heated digester, to the secondary digesters, or direct to the sludge bed. The Manifold is so designed that sludge may be pumped from, or to, any point thus providing for cleaning of suction lines.

The Plant was built under a P. W. A. Grant and the Currie Engineering Company designed the plant and supervised the construction.

SEWAGE TREATMENT AT DELANO

By **Glen Johnson**

Water Superintendent and Operator

The City of Delano is essentially a residential city and has a large contributing agricultural area. The city experienced a particularly rapid growth between the census years 1920 and 1930, its 1920 census being 805 compared to 2630 in 1930. It is estimated the present population is 4000.

During 1922 plans were prepared and bonds voted under the 1915 Bond Act for an extensive sanitary sewerage system and disposal plant. 200 acres of land were purchased one and one-half miles west of Delano in an area of poor soil conditions. To this day the region is sparsely settled and very well adapted for use as a sewer farm.

This disposal system consisted of an Imhoff Tank and the spreading o the effluent upon the sewer farm. The tank, 33 feet square, was originall planned for a population of 2500. With the steady growth of the city, th tanks became greatly overloaded. Floating scum and sludge on the top o the tanks promoted the breading of flies and the effluent contained a larg amount of finely divided solids.

Sludge was handled by gravity only, hence large pits were located o the North and South sides of the tank.

With increased use it became impossible to dry out this sludge and i was necessary to scrape out this unsavory mess with men, mules, and Fresno scraper and dry it on the ground around the plant.

Last May, by order of the Council, I asked C. G. Gillespie, Chief o the Bureau of Sanitary Engineering, to make a personal inspection of th disposal plant and give us his recommendations. His answer was so com plete and to the point that I take the liberty of including it in this report:

Dr. T. L. Meehan, Mayor
Delano, California

Dear Doctor Meehan:

Confirming our conversation of last week in the matter of th adequacy of the city sewage tank and sewage disposal generally, wish to say the City is fortunate in having an unusually well isolate place for sewage disposal and I cannot see that more than simpl sewage clarification is needed. That is the purpose of the presen Imhoff tank. However, in common with tanks designed in th period this one was built, it is now greatly undersize. It is hardl sufficient in capacity for half the population. The result of this i to impair clarification to some extent and more seriously to so reduc the time of sludge digestion that the sludge is sour and troublesom throughout the tank. For a long time this has been one of th meanest and most troublesome of tanks from an operator's viewpoint.

There are several ways the plant can be worked over and utilize more modern ideas. The principal features I would recommend are:

(1) Ample space for sludge digestion or in lieu of this, put hot water heating coils in the new tank so that sludge digestion will proceed in winter as well as summer. Coils cannot be adapted t the present tank. It is possible however, to convert the present tank into a heated digester and simply add a new clarifier. Or it may b preferred to make a new and much larger tank of the same type a at present.

(2) Make it possible to put the digested sludge onto sludge drying beds, built at or above ground. The present sludge beds are in a hole and sludge does not drain. This means sludge pumping at least is necessary.

Yours very truly,
Bureau of Sanitary Engineering
By (signed) C. G. Gillespie, *Chief*

After this report, action followed shortly. The Currie Engineering Co. were engaged to prepare plans for a new sewage disposal plant, and to make application to the P. W. A. for a grant covering 45% of the construction cost of such a plant as well as the installation of 7380 feet of cement pipe storm drains, with 18 manholes and 28 catch basins, 6294 feet of 6 inch, 3874 feet of 4 inch, and 690 feet of 2 inch cast iron water mains. These mains were laid to effect circulation and increase pressure, particularly for fire protection. Also a complete Gamewell 30 station fire alarm signal system using a Diaphone Air horn as the alarm signal.

In due time, our grant was approved, and due to the fact that our funds were secured from our surplus, no time was lost in floating a bond issue. Pettijohn & Haddican, of Delano, were the successful bidders. Cost of Total project$53,392.20 Disposal plant$22,363.00 To this must be added 8% for engineering and superintendence.

Our Engineer planned the plant with the suggestions of the State Board of Health in mind.

Briefly the plant is comprised of the following units: A Primary Clarifier to provide one hour's detention on the maximum flow from a future population of 8000, a Primary Digester with a sludge capacity of one cubic foot per capita, and a Secondary Digester with a sludge capacity of one and one half cubic feet per capita, a Sludge Bed well drained and easy of access, a Sludge Pump with provisions for removal of skimmings and solids from the Primary Clarifier to the digesters and on to the sludge beds, and other necessary operating equipment, including water system, gasometer, and heating equipment for the primary digester. No equipment has been added for further purification of the settled effluent as the isolation of the sewage farm is sufficient to provide adequate spreading of the effluent without its becoming a nuisance.

I shall explain briefly the construction of the various units and the equipment used.

(1) The Primary Clarifier is circular—32 feet in diameter by 7 feet side depth. Capacity 42113 gallons. Dorr Company supplied the equipment which consists of a type T Clarifier mechanism, which includes steel support beams with walkway and railing from one edge of tank to center, worm gear drive head with gearmotor and chain drive, center shaft with tie rods and raking arms, influent well and pipe, movable skimming arm, air skimmer pipes suspended from walkway, and air blower. A one horse motor drives the raking arms and a direct connected 3 horsepower motor operates the fan.

(2) The Primary Digester is a circular tank 26 feet in diameter by 20 feet three inches side depth, capacity 80424 gallons. The equipment is a Type A Dorr Digester Mechanism which includes roof support beams, stationary scum breakers, worm gear drive head with gearmotor and chain drive, center shaft with scum breaker arm, and sludge scraper arm driven by a one horse power motor. This tank is heated to speed up bacterial action, particularly in cold weather. Six sets of vertical heating coils are equally spaced around the circumference of the tank. Thermostatic control maintains an even temperature.

(3) The Secondary Digester is a square tank 33 feet on a side, divide into two sections by a central partition. This is the old Imhoff tank wit the baffle and dividers removed and capped with a reinforced concrete cover Whether the use of the old tank saved much money is problemmatical, how ever, the psychological effect is good, inasmuch as we did not destroy \$7000.00 plant. There are no moving parts in the secondary digester.

(4) The control room contains a Barnes-Dorco type TX 306 Sludg Pump driven by a 3 horse power motor. The manifold has five double set of valves. It is simple to operate and extremely flexible.

This room also contains the switch board, water pressure tank, an Bryant Water Heater, and ¾ horsepower hot water pump. To supply ga for the water heater the Primary Digester and each section of the Secondar Digester are equipped with gas collectors, which are connected to the Ga Holder 4 feet in diameter and 5 feet high.

(5) The last unit is the sludge bed, which is 50 feet long by 80 fee wide. The bed is drained with 6 inch tile and is built up of pea gravel an sand.

To provide information relative to daily flow of sewage, for our En gineer, a weir was set up in the effluent ditch last June.

The readings for 24 hours, from 7 A. M. June 11th to 7 A. M. Jun 12th were as follows:

June 11:	7 A. M.	121.5 gals. per minut
	10 A. M.	210.0 " " "
	1 P. M.	261.0 " " "
	4 P. M.	261.0 " " "
	7 P. M.	236.0 " " "
	10 P. M.	288.0 " " "
June 12:	1 A. M.	315.0 " " "
	4 A. M.	142.0 " " "
	7 A. M.	121.5 " " "

Readings were taken for a week and it was well determined that th above readings were typical.

From these readings we find an average flow of 218 gallons per minut or 77 gallons per capita per day. This per capita flow is higher at this par ticular period than during cool weather, due to the various types of cooling systems which do not recirculate the water. This flow is almost entirely from residences and stores. We do not have a creamery or manufacturing plants.

The location of the plant was, of course, fixed as the old Imhoff tank was to be used. The height of the Clarifier was also fixed by the outfall sewer line. This line at the railroad tracks on Cecil Avenue is 14 feet deep at the sewer farm it is a foot and a half below the surface—a distance o 10858 feet. The grade of this line runs from .0018 to .002.

This outfall sewer is 15" concrete pipe which was laid during the win ter of 1922-23. A year ago last January we found a serious condition exist ing in the arch of this pipe due to the low gradient and the length of th outfall. Hydrogen sulphide gas was forming in the sewage and oxydizing

o a dilute sulphuric acid, had eaten the cement away to a dangerous point.

An application was made to the W. P. A. for a project to repair this ine. The project was approved to provide for recapping the outfall line vith a cement crown not less than 2 inches thick and extending below the enter of the pipe on either side.

This job was successfully completed at a cost to the City of $2,659.22 nd to the W. P. A. of $21,538.00.

We are pleased to acknowledge our indebtedness to the P. W. A. and he W. P. A. for giving our City the opportunity to secure adequate and anitary sewage removal and disposal.

Our City Council composed of the following men:

Mayor T. L. Meehan
B. F. Stradley
A. S. Cole
O. T. Mast
John J. Graham

re to be congratulated for having the vision and the courage to avail themelves of the opportunity to provide the City of Delano with these essential mprovements.

In closing, I would like to pay tribute to a man who has served the City f Delano long and well. He fought the old Imhoff tank when it took lenty of courage and hard work. I refer to a man many of you know as he as attended these meetings—A. Ackerman.

SEWAGE WORKS IMPROVEMENTS FOR THE CITY OF BAKERSFIELD

By **J. Holfelder**
City Engineer

The program of sewage works improvements now in the process of fulillment comprises three units of construction: An intercepting sewer, a ewage pumping station and a treatment plant.

Three separate small areas in the southwestern portion of the City at levations too low to be served by gravity to the main outfall sewer have een served by local collecting systems of sewers to pumping stations in each f the areas for lifting to the nearest gravity sewer.

A sewer, a mile and a half in length, constructed of 15 inch, 18 inch nd 21 inch diameter concrete pipe, will intercept the collecting sewers at ach of the older pumping stations and discharge at the new pumping station n the site of the most eastern of the old stations.

Although the total lift of sewage will be somewhat greater from the ne sump than from the former three, the load factor of the new plant will e improved through flattening of the peaks of flow and the reduction of the umber of pumping units and accessories to maintain.

Other important results to be obtained from the concentration of the

pumping at one plant are: (1) the restriction of peak discharge to that of the capacity of the one plant as against a peak due to possible coincident capacity discharge from the former three plants thus tending to equalize the sewage flow at the treatment plant; (2) the shortening of the time of detention in the sump between periods of pump operation; and (3) makes practicable chemical dosage of the sewage for odor control and to retard septic action not only in the pumping station sump but also in the main outfall sewer into which the pumps discharge.

The new pumping station will have Scott-Darcey Universal type of chlorination equipment for the production of solutions of chlorine or chlorine-iron and the feeding thereof to the sewage before or after pumping.

Operation under the conditions of actual flow will demonstrate the amount and quality of dosage, as well as the point of application, that will best control odors at the pumping plant, retard septic action in the trunk sewer, and keep the sewage as fresh as possible as it enters the treatment plant. The pumping equipment is the Chicago Pump Company's "Flush Kleen" duplex unit system consisting of two vertical pumps with interconnecting piping, strainers, valves, automatic float control and alternator.

Three miles east of the pumping station, and more than four miles from the center of the City, the forty-two inch outfall enters the treatment plant site at the northwest corner of Bakersfield's sewer farm. The average slope of the ground surface of the farm, generally to the southeast, is approximately seven feet to the mile.

The plant consists of: By-pass and flood control structure; screen house and automatically raked ¾" rack screen; triturator; Parshall flume; control building containing pumping units; reaction tanks with chlorine solution equipment, gas burning water heater, water supply and circulation pumps and accessories, sludge pumps, laboratory and provision for future installation of gas engine driven electric generators; flocculator-clarifier; sludge digestion tanks and sludge drying beds.

The control structure diverting the sewage flow from the existing sewer to the plant is provided with gates for the rediversion back to the old channel in case of the necessity of by-passing the plant and an overflow weir for the automatic by-passing of possible flood flow in excess of any desired load on the plant.

In the screen house a bar rack with ¾" openings is mechanically cleaned at intervals of differential levels of the sewage stream above and below the rack. The cleaning rake will elevate the screenings to a triturator so located that the shredded screenings therefrom may be drained and chuted to a screenings buggy for transportation to the scum sump adjacent to the clarifier whence together with the scum they will be pumped to the primary digester.

Provision is made for optional discharge of shredded screenings direct to the sewage stream below the bar rack. Grit removal is provided in a detritor channel double the width of the main sewage conduit and of a depth sufficient to reduce the velocity of flow to approximately one-third of that in the main conduit under the conditions of flow when grit removal will be required. A motor-operated rake will discharge the settled grit to a hop-

ver outside the detritor. The rate of flow of sewage is measured in a Parshall flume constructed in the channel below the detritor and recorded in the control house.

The invert of the sewage channel entering the control house is fifteen feet below clarifier overflow. The sewage sump is constructed of the size to have a storage capacity of the average daily flow for fifty minutes for use in the emergency of a power failure. The pumping plant is designed to operate automatically under the conditions of the varying rates of daily flow with the sewage level at all times below the half capacity of the sump. The pumps are the horizontal centrifugal type located in the pump room adjacent to the sump with center line of pump one foot above bottom of sump.

The present pump installation consists of two identical units of 2500 g.p.m. capacity each with constant speed motors and two units of 1250 g.p.m. capacity at full speed of varispeed drive. One of the larger pumps is expected to operate continuously, or nearly so, its capacity being very close to the average minimum daily sewage flow. Float controls are designed to actuate the vari-speed driven pumps at flows of sewage greater than the capacity of the constant speed unit. The second constant speed unit is designed to operate alternately with the first unit. Provision has been made for a third constant speed unit of 2500 g.p.m. when the sewage flow increases to such an amount that it will operate continuously.

In the control building will be installed the Scott-Darcey Universal type chlorination unit for dosing with ferrous chloride at the screen-house or pump sump for odor control, with ferric chloride in the line ahead of the flocculation-sedimentation tank for coagulation, and with chlorine for conditioning the supernatent liquor from the sludge digestion tanks and for terminal disinfection, when and if necessary. Also in the building are to be located the sludge pumps, hot water boiler and circulating pump, fresh water pressure tank, and the flow recording gage and control board. Provision for adequate office and laboratory facilities is also included in the building.

Some effort has been made to give a pleasing architectural appearance to the control building without any lavish expenditure of money. In this treatment, glass brick has been employed to produce panel effects.

The flocculator-clarifier unit is 100 feet in diameter with a center depth of 17 feet 11½ inches, and a side water depth of 10 feet, with center feed and circumferential discharge. The central zone 50 feet in diameter is designed to operate as a flocculating unit and will be equipped with a Dorr Company flocculating mechanism. The annular ring outside the flocculating unit is the sedimentation unit and will be equipped with Dorr Company scraping and skimming mechanism. Provision is made for dosing with ferric chloride into the influent line when and if peak load conditions require it for adequate solids removal.

The digestion tanks provide for 2-stage digestion with heating coils in the primary digestion tank only. The tanks are each 45 feet in diameter and 22 feet deep with a gas holder on the secondary tank to provide for equalizing the gas flow. The necessary interconnecting piping and valves for control of sludge flow are housed in the valve house which connects the digestion

tanks. All piping for sludge lines, water lines and gas lines is carried in a pipe gallery between the digestion tanks and the control building.

The supernatent liquor from the digestion tank is carried to the pump line leading from the pumps to the flocculation-sedimentation tank and has provision for chlorine dosage in the line to condition the liquor if it should have a tendency to upset the tank operation.

The sludge drying beds are 25 feet by 100 feet in dimensions and are provided with a motor driven belt conveyor and loader. At present four beds only are to be constructed. Provision is made for increasing the number of beds when and as needed.

The water supply for the plant is provided by a well with an automatically controlled pressure system. The outdoor piping system includes provision for adequate irrigation of the grounds. An auxiliary WPA project has been set up to landscape the grounds and plant with lawns and shrubbery.

The plant when completed will meet a long existing need which would have been a gross nuisance but for the plant isolation and the large area of city-owned land available for disposal. Unless the character of the use of the effluent is changed, the degree of treatment provided by the works under construction will meet all sanitary requirements for many years.

CITY OF BAKERSFIELD TREATMENT PLANT DATA

Estimated Population—Incorporated area 31,000
Estimated Population—Contiguous area 40,000
Estimated Tributary Population—195 45,000

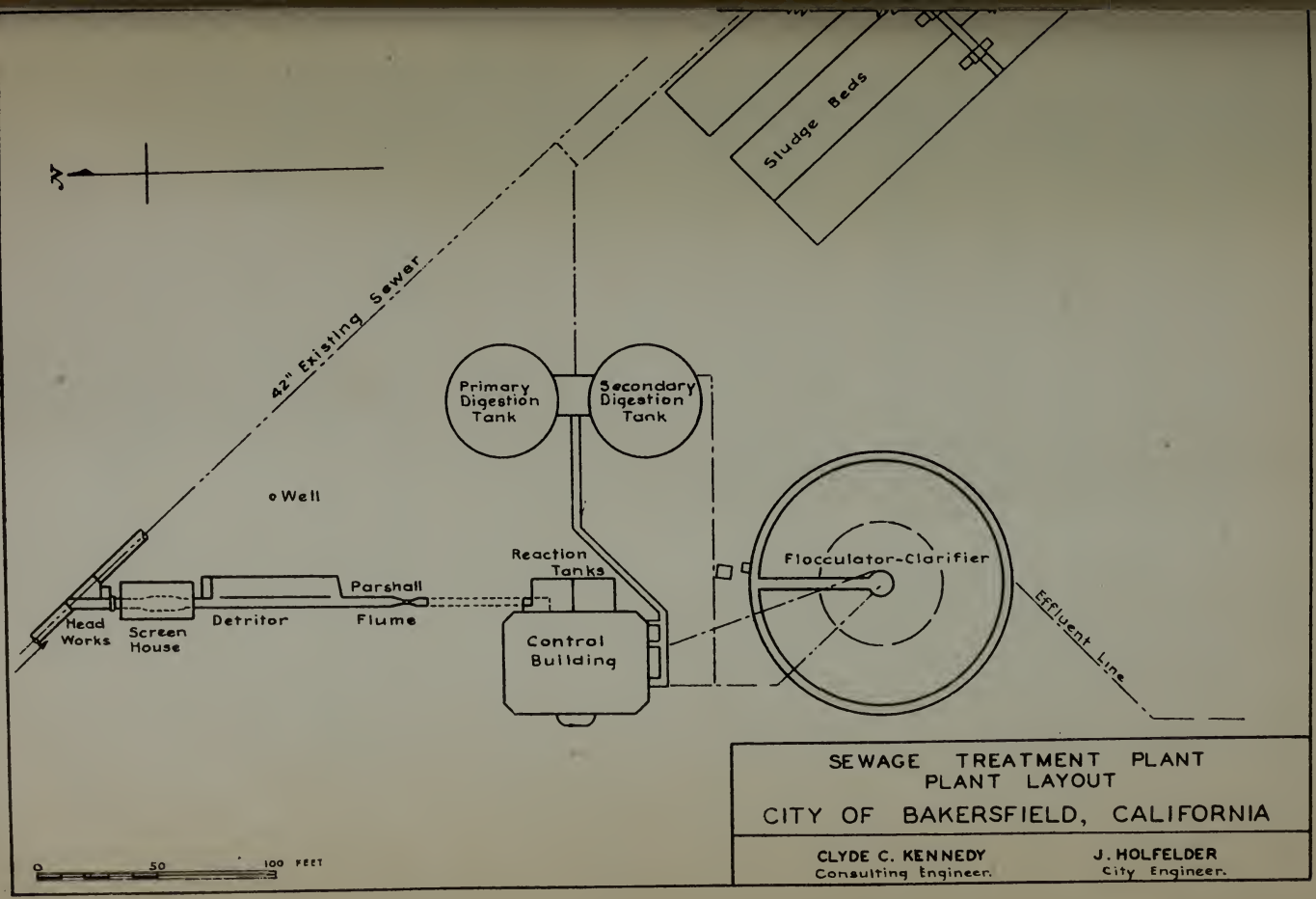
Present sewage flow—average during summer 4.0 m.g.d.
Design sewage flow—average daily 7.0 m.g.d.
Design sewage flow—maximum rate 10.5 m.g.d.

Combined flocculation—sedimentation tank 100 ft. diam.
Detention period—2+ hours at 7 m.g.d. rate of which 30 minutes is flocculating period.

Digestion Tanks—2-45 ft. diam. 22 ft. deep at 35,200 cu. ft. capacity each.
Holding period at 7 m.g.d. flow—primary 15 days
Holding period at 7 m.g.d. flow—secondary 30 days

SEWAGE CHARACTERISTICS

Settleable solids—weighted for week 250 p.p.m.
5 day B.O.D.—weighted for week 234 p.p.m.



SEWAGE TREATMENT PLANT
PLANT LAYOUT
CITY OF BAKERSFIELD, CALIFORNIA

CLYDE C. KENNEDY
Consulting Engineer.

J. HOLFELDER
City Engineer.

Discussion Bakersfield Plant:

Q. What is the size of the vari-drive pump units at the Bakersfield Plant?

A. *Mr. Kennedy:* The units are 15 H. P. the maximum now available.

Q. *Mr. Rawn:* What disposal is made of the plant effluent?

A. *Mr. Kennedy:* The effluent is used to irrigate 600 acres of pasture land, capable of feeding six head of dairy cattle per acre continuously.

Q. *Mr. Gillespie:* Did I understand you correctly that dairy cows were pastured on the sewer farm?

A. *Mr. Kennedy:* Yes, dry cows, the gates are closed to milk cows.

Discussion Delano Plant:

Q. *Mr. Pomeroy:* How long did the old plant serve the City?

A. *Mr. Johnson:* From 1922 until last year.

Q. *Mr. Rawn:* Why and what is the source of the high early morning flow?

A. *Mr. Johnson:* It is due to the fact that the sewage must pass through two miles of main outfall on a very flat grade before reaching the plant.

Discussion Visalia plant:

Q. *Mr. Phelps:* What was the cost of the Visalia Plant?

A. *Mr. Huth:* Approximately $91,000.

Q. *Mr. Wm. Ingram:* Will you kindly review the population equivalent figures of the cannery and creamery wastes?

A. *Mr. Huth:* The population equivalents of cannery and creamery wastes are 3,000 and 1,000, respectively.

Q. *Mr. May:* Has the cannery waste come to the plant yet?

A. *Mr. Huth:* No.

Q. *Mr. May:* Your difficulties then are ahead of you.

Discussion Wasco Plant:

Q. *Prof. Reynolds:* Potato washings are a new kind of waste in sewage plants. If there is not much organic matter in it, why can it not be disposed of in some other way?

A. *Mr. Gregory:* An ordinance was passed by the City of Wasco, providing for the proper washing of potatoes to avoid trouble at the plant, but it has not been enforced.

Q. *Mr. Rawn:* Does the City rent the sewer farm for alfalfa raising?

A. *Mr. Koebig:* The City leases the farm for $600 per year. Alfalfa, barley and corn may be raised.

Q. *Mr. Beyer:* Have any analyses been made to determine the amount of inorganic matter in the potato washings?

A. *Mr. Gregory:* Some tests have been made, but are rather incomplete.

(Time did not permit discussion upon Tehachapi Plant).



SEWAGE AND TRADE WASTES TREATMENT

in

America, Great Britain, Holland and Germany

Reviewed by Charles Gilman Hyde, Professor of Sanitary Engineering, University of California

Report of an enquiry commissioned by His Excellency the Governor of the State of South Australia, and jointly sponsored by the Commonwealth Fund of New York, and the Government of South Australia, into the methods of Treatment of Sewage and Trade Wastes and matters related thereto in America, Great Britain, Holland and Germany.

***By* Henry J. N. Hodgson, M.C.E., M.R. San. I., A.M.I.E. (Aust.)**

Published by the Authority of the Honorable the Commissioner of Public Works Sir Herbert Sydney Hudd, K.B.E., M.C., M.P.

To His Excellency Sir Winston Joseph Dugan, Major General, Knight Commander of the Most Distinguished Order of Saint Michael and Saint George, Commander of the Most Honourable Order of the Bath, Companion of the Distinguished Service Order, Governor in and over the State of South Australia and its Dependencies in the Commonwealth of Australia.

May it please your Excellency:

I have the honour to submit a report in pursuance of the Commission granted to me on the 13th day of June, 1935, and the letter under Seal bearing the signature of the Honourable the Premier and dated the 23rd day of September, 1936, to inquire into the methods of treatment of Sewage and Trade Wastes, and matters related thereto, in America, Great Britain, Holland and Germany.

Part I.—Introduction

METHOD AND SCOPE OF INQUIRY

1. For the purpose of the enquiry I visited America, Great Britain, Holland, and Germany. I travelled extensively in these countries, and was able to secure the latest information on sewage and trade wastes treatment and allied subjects.

The field of this enquiry has been made as wide as possible. I have sought information from Departments of Health, Rivers and Drainage Boards, Sanitary Districts, consulting engineers and chemists, manufacturers of mechanical equipment, experimental research stations, universities, and from numerous city authorities and factory owners, in the above-named countries.

In addition, I have visited a representative group of over 150 modern treatment works in all four countries. I hope, therefore, that the report reflects a broad outlook and up-to-date viewpoint, and that it covers the most recent advances in sewage and trade wastes treatment.

Screens, Racks, Comminutors, Grinders. After a comprehensive survey of the various methods employed and the factors involved in the collection, handling and disposal of screenings, the writer is of the opinion that probably most satisfactory performances may be obtained by the use of bar screens of approximately ¾-in. to 1-in. clear openings, automatically operated and mechanically cleaned, with direct connection to a mechanical grinder, the whole installation being completely enclosed as far as this is possible. The writer is also of the opinion that the passing of the ground screenings, either separately or with sludge direct to the sludge digestion tanks, is to be preferred to returning them to the sewage. As the chief function of sewage treatment is the removal of putrescible matter from the liquid, the writer can see no justification for again returning this material to the liquid once it has been removed.

The writer is also of the opinion that screens should be in duplicate, and preferably the grinders also, although this is not quite so important in the case of the latter. Ground screenings, either separately or in combination with sludge, can be readily handled either with plunger or diaphragm pumps or pneumatic ejectors.

Garbage Disposal With Sewage. The results of the laboratory experimental work, and the large scale undertakings as outlined above, convinces the writer that under American conditions at least, there is no insurmountable difficulty in the treating and disposal of garbage with sewage. It can generally be said, too, that most sewage contains considerable quantity of garbage which would be all the better from the point of view of treatment for being passed through a grinder. Added to this there appears the possibility that with the admission of a limited amount of garbage, and the consequent increase in gas yield from digesters, that a sewage treatment plant may be made independent of outside sources of power as is the case at Durham, N. C.

However, despite the comparatively rosy picture which has been painted above, the writer feels that the editorial of F. W. Mohlman (Sewage Works Journal, Jan. 1936), with its moral "Look before you leap from the frying pan into the fire," is timely. It appears to the writer that under certain conditions of extremely low flow and extremely strong sewages, which in themselves are most difficult to treat—conditions which are frequently encountered in this country—that the addition of garbage may make an already difficult situation at treatment works an impossible one. Consequently the writer feels that very serious thought should be given to the consequences, before admitting garbage in unlimited quantities into sewage systems in this country.

Skimming Tanks: Grease Removal. Until comparatively recent years special equipment for the removal of oil and grease at sewage treatment works was rarely provided; some of this grease was caught in the primary sedimentation tanks, while the major portion of it went on to cause trouble in the various biological units. The writer noted that many new plants, particularly those handling sewage containing certain trade wastes, are providing special skimming tanks, where a short period of aeration is used to liberate the grease from the liquid, the tank being so designed as to catch this liberated grease. Typical installations of this type are those at

Cedar Rapids, Pasadena, Woonsocket, Washington, Madison, and Springfield, U. S. A., and Essen Rellinghauses, Germany. In contrast to these are the plants at Cleveland, U. S. A., and Leipzig, Germany, where the grease is liberated by air blowing, and later separated out and caught in the preliminary sedimentation tanks. At Columbus, Ohio, U. S. A., grease is liberated in the grit chambers by air admitted some distance up from the floor of the chamber, while at Woonsocket, R. I., small amounts of chlorine admitted with the air to the diffuser system have greatly improved grease separation. Various methods are employed for the disposal of the collected grease. At Kettwig, Germany, it is collected and sold. At Essen Rellinghausen, Germany, and Cedar Rapids, U. S. A., it is burnt; while at San Francisco, U. S. A., it is intended to digest it with the sludge in the sludge digestion tanks.

Where sewage contains sufficient greases and oils to warrant the expense of separate skimming tanks, good results may be expected in properly designed tanks employing about 15 minutes aeration period and using approximately 1 volume of air for each 5 to 10 volumes of sewage. Special care is needed in the design of these units, as, of those noted, more were working inefficiently than efficiently. Equally good separation of grease will be obtained by preaeration and collection in the sedimentation tanks; however, if much grease is present this gives a very unsightly sedimentation unit with considerably more trouble in collection and cleaning.

At the average plant the writer is convinced that skimmings may best be disposed of by digestion with the sludge; however, where separate grease skimming tanks are employed and the quantity warrants it, the grease may be either collected for sale or else burnt.

Preaeration. Prearation has been used at a number of important plants, usually for one or more of several reasons:—As a means of liberating grease and light floating material; as an aid to flocculation ahead of sedimentation tanks; to relieve the load on trickling filters and so allow increased dosage rates; to blow out gases of decomposition from the sewage, usually ahead of activated plants, and as an aid in maintaining sewage in a fresh condition. At Providence, R. I., and Columbus, Ohio, U. S. A., provision is made for preaeration ahead of the activated sludge unit, while at Decatur, Illinois, preaeration greatly increased the possible loading on trickling filters.

At Tilburg, Holland, preaeration using Kessener stainless steel revolving brushes is employed in a balancing tank ahead of a chemical precipitation plant as an aid to keeping the sewage fresh, to ensure more thorough mixing of trade wastes discharges and sewage, and as an aid to natural flocculation. Preaeration is open to the serious objection that it often creates odours around a plant, and this has been largely responsible for the fact that it has not been more generally used.

Natural Flocculation; Mechanical Flocculation. Increased interest in natural flocculation is being displayed, notably in the United States of America. Experiments at Los Angeles and San Francisco, California, and Cedar Rapids, Iowa, have demonstrated the fact that removal of solids by sedimentation tanks can be greatly increased by subjecting the sewage, before

sedimentation, to a short period of gentle stirring, either by mechanical means, or by the use of air. This has resulted in mechanical flocculators being incorporated in the designs for the proposed new plant at San Francisco, California, while plants at Sioux Falls, South Dakota, Cedar Rapids, Iowa, Greensboro, N. C., and Coney Island, N. Y., are so equipped that natural flocculation can be employed if found necessary.

Considerable interest is being displayed, principally in the United States of America, in the mechanical flocculation of sewage, without the use of chemicals, ahead of plain sedimentation tanks. Benas, experimenting at San Francisco, found that by gently stirring sewage for 20 to 30 minutes, he got a natural flocculation which aided subsequent sedimentation to the extent of removing 15 to 30 per cent more B. O. D. than in the case of the unstirred sewage. He found that this stirring was best done using a mechanical stirrer, and that air blowing was too violent.

Rawn at the Los Angeles county plant found that 20 minutes gentle stirring with paddles increased the suspended solids removal of his sedimentation tanks by 25 per cent.

Dr. Fischer has informed the writer that, at one period when sludge was settling very badly at Coney Island plant, N. Y., and when only 15 to 30 per cent removal of suspended solids was being obtained with plain sedimentation, 30 minutes flocculation using mechanical stirrers increased the suspended solids removed to over 60 per cent. At this plant mechanical flocculators are installed for use when chemicals are being applied, and Donaldson has informed the writer that extended trials will be made at this plant employing mechanical flocculation without the use of chemicals.

However, San Francisco appears to be the first city to deliberately include this feature in a new plant, and Benas has informed the writer that in the new Richmond-Sunset plant, a 15 million gallon capacity plant, a unit is to be included to give 30 minutes mechanical flocculation at average flow, and 20 minutes at maximum flow, ahead of the sedimentation units. Here arrangements will be made to use chemicals if additional purification is required.

At the Glenelg sewage treatment plant, South Australia, an extensive series of tests using mechanical flocculation in conjunction with sedimentation showed increased removals of B. O. D. and S. S. of from 10 to 25 per cent over plain sedimentation, when handling sewages with B. O. D.'s ranging from 160 to 500 p. p. m.; however, in the case of sewages with higher B. O. D.'s the benefits from flocculation were hardly appreciable, the improvement over plain sedimentation ranging from 2 to 8 per cent, only.

From experimental work done by the writer, and from the results of the trial runs at the various plants outlined above, the writer is of the opinion that this latest development in the sewage treatment field offers great possibilities for improving the performance of sedimentation tanks, and for lightening the load on biological processes. The Glenelg experiments, however, would suggest that in the case of plants treating exceptionally strong sewages, particularly those of a colloidal nature, its use is not justified by the results obtained, except in those situations where chemicals are to be used during hours of peak loading.

Dilution of Sewage Undergoing Treatment. It is a well-known fact that a diluted sewage is very much more easily and cheaply treated than a stronger one. This has caused several works to attempt the dilution of the sewage ahead of biological processes. At Aurora, Illinois, U. S. A., success is claimed for the dilution of the sewage with river water ahead of trickling filters. In England and Holland, considerable interest is being displayed in the dilution of sewage ahead of activated sludge plants, the most favoured method being the use of effluent water as a dilutant. Obviously, the simplest method of returning diluting water is to increase the percentage of return sludge to the aeration tanks, and this is the method employed at Coleshill and Mogden, England. At Salinas, California, U. S. A., and Birmingham and Ellesmere, England, effluent is returned to the incoming sewage ahead of trickling filters, while in the case of many difficult trade wastes, like gas liquor, separate treatment of the waste is only possible after heavy dilution.

Sedimentation. English and American practice still diverges on the question of detention time in these units, American designers generally favouring relatively short detentions, while in England the regulations of the Ministry of Health cause relatively long detention to be employed. German designers appear to follow very closely American practice, while it was noticeable in Scotland that detention times approximating those employed in America were being used in new plants. In England a tendency to build two-stage sedimentation tanks was noted. Here a relatively short period of sedimentation in first stage removes the more readily settleable solids, which are withdrawn at frequent intervals, while a relatively long detention in a secondary tank removes the less settleable solids, and these are withdrawn at less frequent intervals.

Generally speaking it appears that in the United States of America there is a very decided preference at present for the mechanically cleaned tank as against the Dortmund or Imhoff type, while in England and Europe opinion appears to be fairly evenly divided, the latter being built for the smaller installations, and the former for the larger.

Generally speaking, the writer believes that for handling heavy primary sedimentation tank sludges, and this applies especially to separate systems where grit chambers are not employed, and where a certain amount of grit has always to be handled, that "straight line" conveyor equipment will prove slightly more positive in sludge removal, and more robust in operation than the rotating type mechanisms. It is believed that except for very small installations where Dortmund tanks may be used, that generally speaking, mechanically cleaned tanks will prove superior in operation to the hopper type.

Chemical Treatment. In England and Germany, except for the treatment of certain trade wastes, chemical treatment, generally speaking, is gradually being superseded by biological treatment, illustrative of this tendency being the gradual replacement of such chemical precipitation works as Barking plant, London, and Dalmarnock plant, Glasgow, by activated sludge treatment, while in the United States of America the writer believes that the limitations of the process are gradually becoming known, and that its position

relative to other processes, based on performance, is slowly being established.

The writer believes that, because of its inability to remove dissolved impurities, chemical treatment cannot replace biological processes, but that its chief field of usefulness may be found in:—

(a) The treatment of certain industrial wastes, and sewages containing large quantities of these wastes.

(b) For seasonal use, where plain sedimentation is a sufficient degree of treatment generally, but where some additional treatment is needed over a few months of the year.

(c) For use during certain hours of the day or days of the week when sewages are strongest, to lighten the load on biological processes.

(d) For conditioning of sludges preparatory to vacuum filtration.

(e) Chlorine, it is believed, will find its chief field of usefulness in odor control and in the sterilization of effluents, and when used for the former, economy may be expected if it is used in conjunction with iron. Ferric or ferrous chloride, it is believed, will be found to be excellent as an odor control both in the sewage system and at the treatment plant.

(f) The writer believes that the magnetite filter has a wide field of usefulness, and it may be used as a strainer for effluents from plain sedimentation, chemical precipitation or biological processes.

The writer believes, however, that the success being obtained with natural flocculation will still further reduce the field of usefulness of chemical treatment. In this country, costs of chemicals may likewise be expected to still further limit its use, for generally speaking, costs of chemicals here appear to be at least twice ewhat they are in the United States of America.

Where chemical precipitation is to be used, best results may be obtained using ferric-chloride or ferric sulphate as a coagulant, with adjustment to optimum pH using lime except in exceptional cases, and with about 5 minutes rapid mixing using either air or a rotary mixer, followed by 15 to 30 minutes gentle stirring with mechanical stirrers, followed by 1½ to 2 hours sedimentation, the effluent to be filtered with magnetite filters if a still higher degree of treatment is desired.

Where ferrous sulphate or copperas is obtainable at a very low price it may be more economical to use chlorinated copperas as a coagulant, and results nearly as good as those with ferric chloride may be expected.

Trickling Filters. The writer believes that:—

1. For the treatment of very strong sewages, trade wastes, or a combination of the two, trickling filters are probably the most successful single biological process available, while rotating distributors dosing continuously are the best means of sewage application.

2. Such trickling filter installations should not be built within half a mile of any considerable habitation, and they should always be preceded by adequate sedimentation.

3. A combination of bioflocculation and trickling filters, as used at Birmingham, England, should give excellent results in the treatment of strong sewages, and if coupled with recirculation should give little fly or odour nuisances, or trouble from ponding, and should allow of greatly increased filter dosage rates.

4. In the case of sewages containing large quantities of trade wastes, such as the wool washing wastes at Bradford, chemical precipitation with pH adjustment, followed by trickling filters, is probably the best method of treatment to adopt.

5. Good results and some economy may be expected employing high rate filtration for strong sewages; however, if a high degree of treatment is necessary, double filtration should be used.

6. The ideal trickling filter installation for treating strong sewages or trade wastes would appear to be:—

(a) Presedimentation tanks of ample size.
(b) Filters with a minimum of two units so connected that they can be operated in series or parallel, with provision for alternating the leading filter.
(c) A minimum of two humus tanks so connected that they can be used for series or parallel operation and of a size that will allow for the maximum likely recirculation of effluent.
(d) Recirculating equipment for each filter stage capable of handling up to at least five times the sewage flow, and even higher in the case of some difficult trade wastes. This will allow for correcting possible ponding and will enable the quality of the effluent to be varied at will.
(e) Covered filters with forced draught of ample capacity to insure adequate filter ventilation throughout the full depth of the filter at all times, and insure complete absence of flies and odor.
(f) Rotary distributors for continuous filter dosing so designed as to be capable of handling wide variation in rate of flow.

7. A filter installation built along the lines described above should be suitable for installation in any situation where an activated sludge plant could be built; it should give results very little inferior to those of the activated sludge process, while not being so sensitive to strong sewages and trade waste discharges as the latter.

8. The capital cost of such an installation may be expected to be higher than an activated sludge plant installation, while the operating costs should be lower.

Filters: Slow Sand and Rapid Sand. The writer believes that "slow sand filters" have a definite place among the various sewage treatment processes, and that their greatest field of usefulness will be as "polishers" to activated sludge, trickling filter, and chemical precipitation tank effluents, where particularly high grade effluents are required, or where reclamation of water is to be undertaken. Under these conditions they may be expected to give excellent results, with low running and maintenance cost, and absence of nuisance. For small towns where natural sand deposits exist which can be underdrained, they will give, following sedimentation and used either singly or in stages, an inexpensive and relatively efficient method of sewage treatment; used under these conditions, however, they should not be placed nearer habitation than it is desirable to place the ordinary type trickling filter.

In the treatment of many trade wastes, slow sand filters have a definite field of usefulness as a second stage of treatment following trickling filters or chemical precipitation tanks, and they have been extensively used for this purpose.

"Rapid sand filters" with provision for washing may be expected to

perform the same function as slow sand filters, and they require much less area; however they need to be much more scientifically designed, and they need much more attention and skill in operation, and it is expected that their use will be confined to relatively small installations, particularly those where reclamation of sewage effluent is to be practiced.

Activated Sludge. Practically all authorities are agreed that it is not necessary to carry the activated sludge process to the nitrate stage, although a limited degree of nitrification appears desirable to ensure a sludge settling readily. At some plants visited care is taken to ensure the absence of nitrates as it is feared that they will promote algae growth in the stream into which the effluent is discharged.

At Mogden, England, however, Lockett attributes the dense readily settling sludge and absence of sludge trouble to the high degree of nitrification achieved by a liberal use of air.

Dentrification may be a source of trouble in the secondary tanks; this will be dealt with in a subsequent chapter.

Where the activated sludge system is to be employed for treating medium to strong sewages, or sewages containing trade wastes, and particularly where long periods of dry hot weather are likely to be experienced, as is the case in Australia, the writer believes that best results may be expected by the use of:—

(a) Adequate pretreatment.
(b) Provision for evening out the load to the biological units and/or the use of chemicals to reduce peak loadings, to reduce the immediate demand of the sewage for oxygen, and to control odors.
(c) The diffused air activated sludge system.
(d) Reactivation of the sludge to the extent of providing for the possible use of up to 25 per cent of the aeration tank volume for this purpose.
(e) The longtiudinal ridge and furrow system of aeration with the possible use of the spiral flow system over the latter half of the tank.
(f) The provision of a number of sewage inlets spaced at intervals over the early lengths of the aeration tanks.
(g) Separate containers for diffuser plates with ample above-water air controls. Diffuser plates to be clamped down in such a manner as to allow easy removal for cleaning. Diffuser plates to have a porosity rating of "45," plus or minus 10 per cent.
(h) Ample capacity in return sludge pumps to allow of a return of up to 100 per cent of the sewage flow, with provision for "weighting" sludge with inert material if found necessary.
(i) Provision for continuous sludge wasting, with suitable control of same.
(j) Provision for diluting the influent with plant effluent in the case of especially strong sewages.
(k) Dortmund final settling tanks for small to medium sized installations, and hopper-bottom mechanically cleaned tanks for larger installations, the diameter of the latter not to greatly exceed 60 feet.
(l) A sufficient number of units of both aeration tanks and final settling tanks to give flexibility of operation.

Notwithstanding the above, good results can only be expected when there is a proper appreciation of the absolute necessity for maintaining the oxygen demand—oxygen supply ratio at all times, and particularly does this apply at the entrance to the aeration tanks. Under certain exceptional conditions this immediate demand may be so high that it is impossible to satisfy it by ordinary aeration methods, and under these conditions bacterial activity will need to be retarded by the use of chemicals, such as chlorine.

Reclamation of Sewage for Domestic Use. The thought that led up to the building of this experimental plant,* the type of plant used, and the results obtained have been discussed by Goudey in the Journal of the American Water Works Association, Feb. 1931. This subject was discussed with Goudey, to whom the writer is indebted for the following information:-

The reclamation of sewage for industrial purposes at Grand Canyon, Ariz., has been discussed under the heading of "Rapid Sand Filters." For comparison with the above results obtained at Los Angeles, it may be repeated, that out of 345 ten c. c. samples of this reclaimed sewage taken from the storage tank in 1931, only 5½ per cent of them gave positive tests for B. coli, while out of the 305 samples taken from the make-up tank, only 6½ per cent gave positive tests.

In the Ruhr Valley in Germany, sewage is repeatedly reused for domestic purposes during dry periods. Dr. Imhoff has stated that during the dry summer of 1929, the yield of the Ruhr River became so low that no "upland water" reached its mouth over a period of several weeks.

Imhoff and Sierp conclude that city sewage can be purified and reused in rotation as many as ten times, and that to combat the increasing salinity all a city would need to do would be to supplement its water supply by 10 per cent of fresh water, plus an allowance for evaporation and losses. The writers conclude that these demonstrated facts have great significance in arid regions.

Odor Control. Chlorine, and to a lesser extent ferric chloride, continues to be widely used as a deodorant at sewage treatment works, Los Angeles County being a typical instance of the employment of the former, and Princeton, N. J., of the latter. At Stahnsdorf, Germany, preaeration in a gas sealed chamber with subsequent burning of the "blown-off" gases has proved very successful in keeping down odors, while at Decatur, Ill., grit chambers and screens are covered and the foul gases drawn off and deodorized in an incinerator. At Pasadena, the exhaust gases from the rotary kiln sludge dryer are passed through Royster-Cottrell stove type deodorizers, which have proved very successful. At a number of plants like Halifax, England, the foul air from sludge drying is passed through a spray to settle out the solids and is later deodorized in a furnace, while at Columbus and Cleveland, Ohio, U. S. A., where the disposal works are built in close proximity to dwellings, the pretreatment units are completely housed over.

Treatment and Disposal of Sludge. Summarizing the position, the writer believes that:—

(a) Open drying beds of the conventional type will prove more economical than glass covered beds, and under average Australian conditions will prove the best method to adopt for the drying of digested sludge.
(b) For large cities mechanical filtration may be preferred to sand drying beds because of the very large area required for the latter.
(c) Where sewage treatment plants are in close proximity to dwellings, or places where people congregate in numbers, mechanical filtration is to be preferred to drying beds.
(d) In very dry areas, and where temperatures are high, shallow lagoons should prove to be satisfactory and will be found to cost less than drying beds.

*At Los Angeles.

(e) Where filtrate may contaminate underground or surface water supplies, or in any other way cause a nuisance, it should be collected, and either treated separately or returned to the sewage treatment plant.

(f) Except for use at very large plants, mechanical desludging equipment is not warranted. On the other hand, semi-mechanical methods, such as used at Durham and Springfield, U. S. A., should be found to be excellent.

(g) Drying beds may, under certain conditions, be located at some distance from the main treatment plant. Such a conditions would arise where cost of land is high, or where dwellings may exist in close proximity to the main plant. The drying beds only, however should be isolated, and both primary and secondary digestion tanks could be located at the main treatment works, where supernatant can be withdrawn from the latter and receive proper treatment. This arrangement suffers the disadvantage that it places the drying beds beyond the direct supervision of the treatment works superintendent.

Summarizing the position relative to vacuum filtration the writer believes that:—

(a) Vacuum filtration is a thoroughly proved method of dewatering sludge, and should be very suitable for use where treatment plants are located in close proximity to habitation, where the area of land available is limited, or where it is essential to dewater sludges continuously irrespective of weather conditions. Generally speaking, however, it will be found more costly than drying on sand beds.

(b) In the case of large cities vacuum filtration as a means of dewatering sludge is likely to be more suitable than drying on sand beds because of the large area needed for the latter.

(c) Sludge digestion prior to filtration should be adopted, although it is difficult to justify this course if dewatered sludge is to be subsequently incinerated. Best results will be obtained if digestion is not carried to completion, a commonly adopted period for two-stage digestion being 20 days primary digestion and 30 days secondary.

(d) Elutriation has proved itself, and may be expected to considerably reduce the cost of vacuum filtration; however, some trouble may be expected from the elutriate, and it is believed that this should be classed in the same category as digester supernatant, and not returned to the plant, but given separate treatment.

The writer believes that centrifugal dewatering of sludge will find use as an intermediate stage prior to digestion or vacuum filtration, particularly in the case of activated sludge, and this subject has been discussed in a preceding chapter.

This process* has been successfully used by Downes at Plainfield to reduce the moisture content of digested primary and humus sludge to below 90 per cent. Here the sludge is run into wooden tanks, where 4 lbs. of alum per wet ton of sludge is added, and the contents allowed to stand for a period of four hours. The sludge floats, and the separated liquid is withdrawn from the bottom, the moisture content of the sludge averaging 88 per cent. Downes has also used alum for floating the solids in digestion tank supernatant, and a relatively clear liquid is obtained which is returned to the influent of the plant.

Summarizing the position relative to the disposal of dried sludge, the manufacture of fertilizer, etc., the writer believes that:—

(a) Sludge treatment and disposal without nuisance is the first and primary consideration, and fertilizer production is secondary in importance and should be subordinated to the former.

*Flotation.

(b) The construction of expensive plant for the production of fertilizer is not justified by the returns obtainable.

(c) The abolition of primary sedimentation, and the conversion of all sludge to activated sludge, which is necessary to produce a fair grade fertilizer from all the sewage solids, is not desirable from the point of view of sewage treatment.

(d) A small inexpensive grinding plant is a desirable acquisition to any sewage treatment works, as it greatly extends the field of usefulness of the sludge, and enables a fine product to be produced from the dried digested sludge, which will command a much higher price than the unground sludge.

(e) Dried digested sludge may best be handled by the authority and removed from drying beds or the like to heaps (if area is available), where drying will continue and from where it can be sold direct in bulk to purchasers, or a percentage "fine ground" and sold in bags, the percentage of sales of each depending on the demand and the price obtainable for each. Drying to below 30 per cent moisture is necessary for grinding, and this may necessitate storing under cover during a portion of the year. Disintegration of the partially dried product may be expected to hasten drying.

(f) Digested or undigested sewage sludge should not be used for the growing of vegetables that may be eaten uncooked.

(g) Ground digested sludge, even though its manurial value is not high, should have a ready sale for use on golf courses, public parks, lawns, gardens, orchards (particularly citrus fruit), and for use in the growing of such vegetables as spinach, cabbages, cauliflowers, brussels sprouts, etc. Unground sludge should be readily disposed of for the above uses, except where a fine ground product such as is necessary for lawns or gardens is needed.

(h) Ground sludge should have a ready sale as a "body" or "filler" to manufacturers of fertilizers.

(i) Under Australian conditions there should be no difficulty in disposing of all sludge produced at prices which will at least meet operating and maintenance expenses beyond the digestion tanks or filter plant, and small profits may even be expected if the product is put up in an attractive form.

Summarizing the position relative to sludge incineration, the writer believes that:—

(a) In an agricultural country like Australia, where sludge can readily be utilized to advantage on land, and where climatic conditions are such as to facilitate digestion and drying of sludges, incineration has no place except perhaps in the very largest of our cities, where the quantity of sludge to be disposed of would be great and the transport charges heavy.

(b) Where incineration is to be used, incinerators of the Nichols-Herreshoff or Chicago type may be expected to dispose of sludge without nuisance, and with the more recently designed incinerators this may be expected to be accomplished without the use of supplementary fuel.

(c) Digestion prior to incineration appears difficult to justify, although sludge thickening, and a small amount of storage to help even out the load to the plant, appears desirable.

Memorandum. The Report, with a comprehensive Table of Contents, an Appendix giving the reactions involved in Chemical Precipitation, and 193 excellent References, embraces 534 pages. In addition there are inserted at least 26 full-page photographic reproductions. The Report is replete with drawings and tabular matter. Reducing the drawings and tables to equivalent textual space, the Report would contain at least 400,000 words.

The equivalent of about 85,000 words is devoted to Trade Wastes Treatment. From this portion of Mr. Hodgson's report, the following extracts are particularly interesting as related to California problems.

Wastes from Distilleries, Breweries, Malt Houses, Starch Factories, Corn Products Plants and Wineries. Summarizing the position

relative to the treatment of wastes from the various fermentation and distillation processes as outlined above, namely, distillery wastes, brewery wastes, malt house wastes, starch factory wastes, corn product wastes and winery wastes, the writer believes that the first attack should be in the factory, and that much can be done here by the use of "recovery" methods to render these wastes less fearsome.

He believes that most of these wastes can be treated by digestion in several stages with control of the volatile acids, and/or heavy dilution with effluent, followed by two-stage filtration employing recirculation of effluent.

Humus tanks should be provided after each filter, and provision should be made for alternating the leading filter, while preliminary fine screening would be needed in the case of some of the wastes.

In the case of seasonal wastes several alternatives have been suggested, and here the method adopted will depend largely on the peculiarities of each individual situation.

Based on the Glenelg, South Australia, experiments, good results may be expected in the treatment of winery wastes employing lime precipitation followed by dilution, with subsequent treatment on two-stage biological filters.

Tannery Wastes. Summarizing the position the writer believes that a stable effluent can be obtained by the treatment of all of the wastes from the tanning process together, employing chemical precipitation, followed by treatment on trickling filters, humus tanks, and sand beds. The sludge may be dewatered on sand beds or by vacuum filters.

Cannery Wastes. Summarizing the position the writer believes that these wastes can best be treated by fine screening and chemical precipitation, followed by biological treatment employing trickling filters, humus tanks, and sand filters, or alternatively two-stage trickling filters employing recirculation.

Milk Plant Wastes. Summarizing the position it is evident from the works described in the United States of America, England, and Europe, that milk wastes may be treated either by various types of biological filters or by the activated sludge process. However, based on the very convincing results obtained by the Department for Scientific and Industrial Research at Ellesmere, England, the writer believes that best results may be obtained by the use of sedimentation, with dilution of effluent, followed by two-stage filtration, with provision for alternating the leading filter, and for recirculation of effluent. A humus tank following each filter would be necessary.

Beet Sugar Wastes. Summarizing the position, it appears in the light of present knowledge that "flume" and "wash" water after grit removal and screening, and "process" water, may best be treated by chemical precipitation. If additional treatment is needed for the process water, the effluent may be treated on biological filters. However, provision would need to be made to ensure having a mature filter at the commencement of the beet sugar season, and this will probably only be found possible at small factories. Lime cake may be best handled separately, while Steffen's waste may be dried by "spray drying." Sludge can be readily dewatered on vacuum filters.

OCCUPATIONAL HEALTH HAZARDS IN AND AROUND SEWAGE DISPOSAL PLANTS

By **J. P. Russell, M.D., Chief Industrial Hygiene Service**
California State Department of Public Health

The health hazards to which sewage disposal plant operators and sewer workers may be subjected in the course of their work, include exposure to gases and vapors, infections, oxygen deficiency, and environmental conditions such as excessive dampness. Gases and disease-producing germs are particularly dangerous, because they are invisible and often strike without warning.

During sewage collection, treatment and disposal, a number of toxic, asphyxiating, and inflammable gases may be liberated into the air in confined spaces, where they may accumulate to a dangerous concentration. Hydrogen sulphide, ammonia, and sulphur dioxide are examples of toxic or poisonous gases. Carbon monoxide, carbon dioxide, and nitrogen, are dangerous because of their asphyxiating or suffocating effect when breathed. Methane, hydrogen, and hydrocarbon vapors, such as gasoline, are highly explosive in certain concentrations. Many of these gases are both poisonous and explosive.

Hydrogen sulphide is generated during the decomposition of sewage. It is a gas slightly heavier than air, with a very disagreeable "rotten egg" odor in low concentrations. This odor cannot be relied upon as a warning agent, because at higher concentrations, or after prolonged exposure to small amounts, the odor disappears, due to the anesthetic or numbing effect of the gas on the olfactory nerve. It is inflammable in concentrations between 4% and 46%. Hydrogen sulphide is an extremely poisonous gas, with a toxicity comparable to that of hydrogen cyanide. In low concentrations it causes headache, dizziness, and eye inflammation. Prolonged exposure may result in bronchitis, chest pains, and nervous depression. The maximum concentration which may be breathed for a period of several hours without danger to health, is less than 0.005%, or 50 parts of the gas in one million parts of air. Inhalation of air containing 0.1% or more of hydrogen sulphide for longer than a few minutes, may cause death by paralysis of nerve centers which control respiration and heart action.

Ammonia is a colorless gas with a sharply penetrating odor. It is inflammable in concentrations between 16% and 27%. Its presence in sewers is usually the result of decomposition of nitrogenous organic material. The maximum safe concentration of this gas for prolonged exposure is 0.01%. Concentrations higher than 0.25% will cause dangerous illness in less than an hour. The symptoms of poisoning by ammonia gas include acute inflammation of the respiratory tract, cough, bronchial catarrh, eye irritation, shortness of breath, and salivation.

Occasionally sulphur dioxide gas is present as a result of the burning of sulphur-containing insulating material. Exposure to more than 0.001% of this gas for prolonged periods may have a detrimental effect on health. Sulphur dioxide has a characteristic pungent odor of burning sulphur, and is very irritating to the eyes, nose, and throat, causing choking and coughing when breathed. Cases of poisoning by this gas are unusual, due to its warning odor and irrespirable nature, even when highly diluted with air.

Gasoline vapors emanating from petroleum products discharged into sewers are both inflammable and toxic. They are several times as heavy as air, and tend to settle and accumulate just above the ground or water-level. They are explosive in concentrations between 1.4% and 6% by volume. When inhaled in concentrations of over 0.1%, they cause headache, dizziness, nausea, coughing, and irritation of the eyes and nose. Delirium, anesthesia, loss of consciousness and death, have resulted in less than an hour from the inhalation of air containing 2% of gasoline vapor. In studies conducted by the U. S. Bureau of Mines, it was found that 1% of this vapor is the maximum which can be tolerated by man, due to its irritating effect on the skin, as well as on mucous membranes. Sewer lines from garages and filling stations should be equipped with traps to catch gasoline and oil which may be discharged into the sewer.

Carbon dioxide is a non-inflammable gas which is slightly heavier than air. It is one of the constituents of sewer gas, and is generated in digesters, Imhoff tanks, and septic tanks. Its injurious effect is due to asphyxiation or oxygen starvation of tissues. The maximum amount of this gas which may be breathed safely for several hours is between 2% and 3%. In higher concentrations it causes progressively increasing discomfort, with rapid, labored breathing, shortness of breath, and rise in blood pressure.

Carbon monoxide is also an asphyxiating gas. It is slightly lighter than air, and is inflammable in high concentrations. It is produced by the incomplete oxidation of carbon-containing materials. Carbon monoxide is not a true poison in the sense that it destroys tissue directly. Nevertheless it is dangerous to breathe, even in very small quantities, due to its ability to deprive body tissues of oxygen. This is brought about by the combination of carbon monoxide with haemoglobin, the oxygen-carrying element of the blood, forming a relatively stable compound and rendering the haemoglobin incapable of carrying oxygen from the lungs to the tissues and organs of the body. Since the affinity or attraction of carbon monoxide for haemoglobin is about 300 times that of oxygen, small percentages of carbon monoxide in the air breathed are capable of taking large quantities of blood out of circulation as far as its oxygen-carrying power is concerned. The prolonged inhalation of air containing more than 0.01% of carbon monoxide causes headache, dizziness, weakness, and mental confusion. Larger amounts of the gas may cause nausea and vomiting, loss of strength and muscular control, collapse, and loss of consciousness. All of these effects are greatly increased by physical exertion, due to the increased oxygen demand of body tissues. When more than 0.5% of carbon monoxide is present in the air breathed, unconsciousness and death may occur in a few minutes, without any warning symptoms, especially when vigorous muscular effort is being put forth.

Deficiency of oxygen in the air breathed may be due to the consumption of oxygen by sewage decomposition, or to the presence of inert gases such as natural gas, methane, and nitrogen. Man breathes easiest and works best when the air contains about 21% of oxygen. When this is reduced to about 17% he breathes a little faster and deeper, about the same as when he first goes from sea level to an altitude of 5000 ft. When the inspired air contains less than 16% of oxygen, dizziness, headache, rapid heart action, and buzz-

ing in the ears become troublesome. Men working in atmospheres containing less than 10% of oxygen may lose consciousness in a few minutes.

In addition to its oxygen-replacing effect, methane is dangerous in enclosed spaces because of its highly explosive properties in concentrations between 5% and 16%. It is lighter than air, and tends to accumulate at the top of sewers and tanks.

Manhole covers should be vented in order that gases and vapors which are lighter than air may escape. Before men enter sewers or other enclosed places where toxic or inflammable gases may be present, tests of the air should be made to detect such gases, and to determine the oxygen content of the air. The atmosphere in a sewer should be considered hazardous until it is proved to be otherwise. The sewer should be well ventilated by opening one or more manholes above and below the point where the man is to enter. Ventilation can be accelerated by forcing in fresh air with a power blower connected to a hose. Forced ventilation of sewage tanks should be continued during the entire time men are working in them making inspections or repairs, since gases are being given off and may reach dangerous concentrations unless they are continually diluted with air. If illumination is required, only spark-proof flash lights approved by the U. S. Bureau of Mines should be used.

Portable instruments have been developed for the accurate determination of many toxic and inflammable gases and vapors, including carbon monoxide, carbon dioxide, hydrogen sulphide, methane, and other combustible gases. If possible, tests should be made with these instruments before workers enter atmospheres which may contain such gases. When descending into tanks or sewers, even though no dangerous gases are considered to be present, men should wear safety belts to which are attached ropes leading to the surface, where at least one man should be stationed at all times when a man is working in the confined space.

Canaries, and small animals such as Japanese waltzing mice have been used to detect oxygen deficiency and the presence of poisonous gases. A flame safety lamp, in which a double screen of fine mesh steel wire gauze is interposed between the flame and the surrounding atmosphere, is useful in determining oxygen content of the air. The flame will not burn in the presence of less than 16% of oxygen. However, this lamp is unsatisfactory for the measurement of inflammable gases, since the flame must be observed at close range for this purpose. Also, it may cause an explosion if it is improperly assembled and adjusted. The use of blow torches, charcoal stoves, and open flames of any sort should be strictly prohibited in manholes, sewers, and sewage tanks.

When it is necessary for men to enter atmospheres containing dangerous gases, they should be provided with some form of personal respiratory protection in addition to the precautions already mentioned. The most satisfactory of these devices is the hose-type mask, which supplies fresh air to the wearer from an outside source through a gas-tight hose by means of a hand-operated rotary blower pump. This type of mask has the advantages of simplicity, durability, and the fact that an excess of air is delivered to the face-piece, so that any leakage is in an outward direction. It may be used

up to a distance of 100 ft. from the source of fresh air. Hose longer than this is usually not practicable.

Other personal protective devices include the small self-rescue respirator, which will protect against small concentrations of carbon monoxide for about half an hour; and the cannister-type gas mask, designed to neutralize, absorb, or filter toxic gases from the air before it is breathed. Such masks provide effective protection against certain gases and vapors, in limited concentrations, only under special conditions, and for short periods of time. They should never be used under any conditions other than those for which they have been tested and approved. Moreover, they cannot make up the oxygen deficit in atmospheres which are low in this element. In such cases, the self-contained oxygen-breathing apparatus will provide adequate protection for short periods in emergencies. This device is less satisfactory for routine use than the hose mask.

At same sewage disposal plants, gases are collected and used for heating purposes. This procedure involves very little danger while the plant is in continuous operation, because the gas contains very little oxygen and is as safe to use for fuel as ordinary manufactured or natural gas. However, if the plant is shut down or gas generation is stopped temporarily, an explosive mixture may be produced by leakage of air into the distribution system.

When a man is overcome by inhalation of toxic or asphyxiating gas or by lack of oxygen, he should be removed immediately to fresh air. If breathing has stopped or is weak and intermittent, artificial respiration by the Schaefer prone-pressure method should be given persistently until normal breathing is resumed. The administration of pure oxygen, or a mixture of 93% oxygen and 7% carbon dioxide, is a valuable aid to recovery, but must be used only in conjunction with manual artificial respiration, and never as a means of forcing oxygen into the lungs of a man who has stopped breathing. Circulation should be aided by rubbing the limbs and by hot applications. Physical exertion should be avoided, and any after-effects treated symptomatically.

Everyone working in and about sewage treatment plants and sewer systems should be trained in first-aid measures, including the Schaefer method of artificial respiration. This is particularly important in the case of plant operators and foremen of working crews. Well stocked first-aid kits should be kept on hand at all times.

Sewage may contain pathogenic organisms, such as typhoid and dysentery bacilli, spirochetes which cause jaundice, and pus-producing organisms such as the streptococcus, staphylococcus, and colon bacillus. Some of these organisms cause disease when taken into the body by way of the mouth. A small abrasion of the skin may provide a portal of entry for germs which are capable of causing infection, blood poisoning, and death. All cuts and scratches, however slight, should be treated at once with a strong antiseptic, and covered with a protective dressing. Rubber gloves should be worn whenever there is a possibility of sewage coming in contact with the hands. Scrupulous personal cleanliness, particularly the liberal use of soap and water, is a most valuable prophylactic against infections. Adequate washing facilities and sterilizing solutions should be available.

Typhoid and paratyphoid fevers are infectious diseases against which man can be given almost perfect protection by artificial immunization. Everyone whose work involves contact with sewage should avail himself of this protection. Since immunity produced in this way is not always permanent, all sewage plant operators and sewer workers should have a course of three injections of typhoid vaccine repeated at intervals of not longer than three years, in order to insure their protection against this disease.

Working under conditions of excessive dampness may predispose to diseases of the respiratory system, neuralgia, and rheumatism. The wearing of suitable waterproof clothing, such as rubber boots, provides the most effective protection against the harmful effects of dampness to which plant operators and sewer workers may be exposed.

Occupational health hazards can be minimized by commonsense precautions and control measures. The Industrial Hygiene Service of the State Health Department has field instruments and laboratory facilities available for the quantitative determination of many of the gases and vapors which may be encountered in the operation, maintenance, and repair of sewage treatment plants and disposal systems. We are glad to cooperate in studying and evaluating these potentially dangerous conditions, and in working out practical, effective methods for their control.

Discussion:

Q. *Mr. Pomeroy:* Is typhoid fever more prevalent among sewage workers in comparison with the public at large?

A. *Dr. Russell:* While statistics may not show the percentage of typhoid fever cases among sewage workers to be large, the cases which do occur could have been prevented by immunization.

Q. *Mr Gray:* The late Andrew M. Jensen's death has been attributed to hydrogen sulphide gas in a sewer. Could this be the cause of his death?

A. *Dr. Russell:* Hydrogen sulphide gas may cause almost instantaneous death when the concentration in the air breathed is over 0.2%, because of a combined paralytic effect on the heart and upon breathing.

Mr. Pomeroy: It is unlikely that hydrogen sulphide is often a serious health menace in sewers. If the sulphide concentration in sewage of ordinary pH is 10 p.p.m., the equilibrium concentration of hydrogen sulphide in the atmosphere is only about 0.1%. The actual concentration will always be much below the equilibrium concentration. A much more serious menace, and one which is often overlooked, is oxygen deficiency. Any sewer atmosphere which has enough hydrogen sulphide to be a health menace is sure to have sub-normal oxygen concentrations. Perhaps there are situations where a combination of hydrogen sulphide and oxygen deficiency may cause death even though neither condition alone would be fatal.

Mr. Ramsier: Sulphide concentrations as high as 60 p.p.m. have been found in the sewage in Imperial Valley where Mr. Jensen's death occurred.

Q. *Mr. Tennant:* What disinfectants do you recommend for the general use of operators around a sewage plant?

A. *Dr. Russell:* 7% tincture of iodine is an excellent germicide. Mercurochrome solution is good, if of sufficient strength. Most commercial mercurochrome solutions are 2% or 3%, which is too weak for best results. Most skin infections can be avoided by frequent washing of the hands in a cresol solution, ½ ounce of cresol to one gallon of water, which makes a good disinfectant. Tri-cresol, or liquor cresolis comp., is superior to plain cresol for this purpose.

Q. *Mr. O'Connell:* What do you suggest as an eye wash, if one gets sludge in the eye?

A. *Dr. Russell:* The most effective treatment is to wash out the eyes immediately with large quantities of clean water, followed by a boric acid solution eye wash.
Mr. Batty: There have been no reported cases of disease contracted from sewage in Los Angeles.
Mr. H. G. Smith: During a sand survey of beaches in the vicinity of Hyperion Treatment Plant it was necessary for surveyors to work in the breakers. Three of the men developed dysentery at the time.
Mr. Woodward: It is my blief that all sewage treatment plant operators should complete the Red Cross first aid course, which can be secured from your local fire departments.

TRANSITE SEWER PIPE

By **J. H. Peterson**
Staff Manager Pacific Region Transite Pipe Department
Johns-Manville Corp.

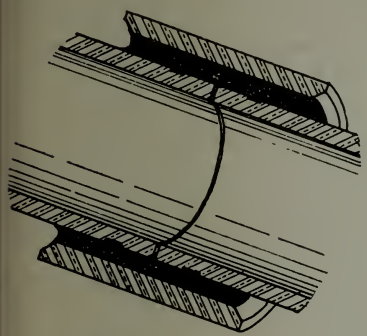
A quarter of a century ago, a group of engineers were confronted with the problem of installing a pipe line to convey corrosive sea water for use in cleaning the streets of a small Italian city. Asbestos-Cement Pipe was used for the project. This pipe withstood the adverse conditions so well that it was soon put to use in other fields where additional advantages—equally important to corrosion resistance—were quickly recognized.

Today, there are approximately 40,000 miles of Asbestos-Cement Pipe serving in sewerage, water works, and industrial systems, and special installations in practically all leading countries. In the United States, over 1,000 cities are using it in sewerage and water works systems. Twenty-two factories have been built throughout the world to fulfill demands for this pipe. The most recent Transite Pipe plant was put into operation here at Watson, California, last October. Other factories manufacturing this product in the United States are located at Waukegan, Illinois, and at Manville, New Jersey.

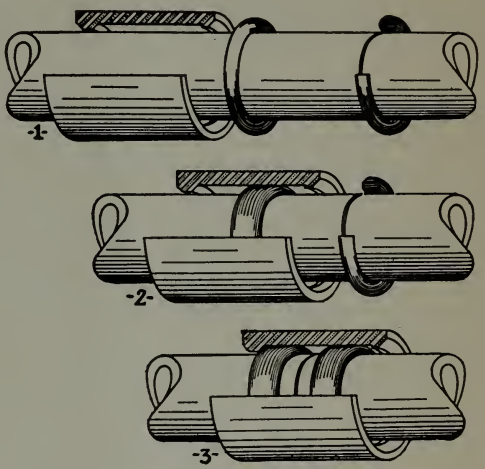
Transite Sewer Pipe is manufactured in its entirety on machines representing the latest development in machine design and construction. The pipe is built up from a mixture of asbestos fibre and cement, carefully proportioned and mixed to give the most favorable combination of strength and toughness. Following thorough intermixing of the asbestos and cement, a predetermined quantity of water is added until the mix takes the consistency of a thin paste. This slurry is fed continuously to a polished steel mandrel on which the pipe is formed. The mandrel is rotated until the required wall thickness is obtained. Each revolution adds a few thousandths of an inch thickness to the pipe wall. Heavy pressure rolls extending clear across the length of the pipe and applying tremendous pressures consolidate the wall into a dense, homogeneous structure. The asbestos fibres are thoroughly interlocked with the cement, uniformly reinforcing the structure, and providing a degree of strength and toughness not generally associated with cement products.

Two types of pipe are available. One is specifically designed for gravity lines, and the other for force mains. For gravity lines, Transite sleeve-type

joints are employed in assembling pipe. The sleeve is placed over the ends of the pipe and then poured with a special asphaltic compound. The ends of the pipe are furnished grooved and primed. This design produces a keyed joint in which the bond between the joint compound and the pipe wall is as strong as the compound itself.



Diagrammatic drawing of the Sewer Pipe coupling showing the design of the joint used in gravity type lines. The sleeve is of free-floating construction and extends over both ends of abutting pipe. The ends of the pipe are grooved and primed at the factory to furnish a tight mechanical bond between pipe and compound.



Schematic drawing of the Simplex Coupling used in pressure mains. The steps show how the coupling is progressively pulled over the ends of the pipe, rolling into position two rubber rings which give a flexible, bottle-tight joint. In practice a manually operated hydraulic coupling puller is used to perform this operation.

For pressure lines the Simplex Coupling is employed. This coupling consists of a Transite sleeve which is pulled over abutting ends of pipe, rolling into position, and confining, two rubber rings. Pipe ends are machined at the factory to effect tight seal. The finished joint permits deflections of 5° and more between adjacent sections of pipe. Pressure pipe is furnished in sizes from 2 to 36 inches and in Classes 50, 100, 150, and 200 for working pressures of 50, 100, 150, and 200 lbs. per sq. in., respectively.

For making house connections into gravity sewers, a "cut-in" fitting is generally recommended, since Transite lends itself to this type of connection and at the same time allows house connections to be introduced into the line as they become necessary. This feature eliminates the problem of initially installing unnecessary branch connections. The "cut-in" fitting consists of a metal casting which may be inserted at any point along the line by merely cutting out a hole sufficiently large to accommodate insertion. Since Transite cuts cleanly and neatly, and neither fragmentizes nor cracks, the operation is simply performed. House connections are made directly into the bell of the "cut-in" section. Where branch fittings are preferred, laterals are also available.

By virtue of its properties, Transite Sewer pipe offers a variety of econo-

mies starting with installation, and continuing throughout service. These not only include savings in the actual cost of installing the pipe, but also include those made possible through a more economical design of the system. The weight of Transite per foot is about half as much as for other materials. This, of course, results in easy handling and aligning, both in, and around the trench. Thus, two men can lower a 13-foot length of ten inch Class 1 Sewer pipe into a deep trench, using rope slings and hand labor, with hoisting equipment unnecessary.

Long 13-foot sections facilitate the laying of the pipe. Comparatively flat gradients can be used, for alignment of the pipe is simplified, and once placed into position, long lengths are more stably restrained, thereby retaining their grade. Because of its light weight the pipe has been easily manouvered into position through intricate bracing in trenches as deep as 30 feet.

Today, with sewage treatment plants contemplated for the smallest towns, the problem of minimizing plant and operating costs is foremost in the minds of progressive operators. Because infiltration of ground water into sewers sometimes represents as much as 25% and more of the total flow, operators and designing engineers are too frequently confronted with the problem of building and maintaining plants of capacities larger than that required to treat legitimate sewage. Therefore, keen interest is being focused on any means available which will allow the design of plants of minimum capacity, and at the same time reduce the expense involved in treating ground water. It has been estimated that a town of only 5,000 population can economically afford to spend an additional $25,000 to eliminate moderate amounts of infiltration from its line.

Not only do joints occur at greater intervals in the 13-foot sections, but the joint itself is a specially designed, free-floating type which reduces infiltration to a minimum. Thus, on the Westchester County Sewer project in New York, it was necessary to choose a material for a 7,000 foot gravity line skirting Long Island Sound and alternately located above and below tide water. Accordingly, a specification was drawn up which not only demanded a pipe highly resistant to the corrosive action of sea water, but one which also included what was considered a stringent requirement against infiltration—i.e., a loss of not over one gallon per inch diameter of pipe per 100 feet, per hour, under a four foot pressure head. Infiltration tests conducted after a heavy storm and shortly after high tide, with the line submerged, showed maximum infiltration equal to 15% of the allowable.

Because the joint is of semi-rigid construction, it permits the line to accommodate itself to minor earth movements without permitting the joint to open. On one installation a line was laid along the edge of a railroad embankment where ability to withstand vibration was a determining factor in the choice of material, and in another project, the pipe was installed at a depth of seven feet in a soil so unstable that sheet piling had to be driven at a depth of fifty-six feet to prevent sand-boils.

In discussing all-around economy, the subject of high strength must be given due consideration. Frequently, sewer lines are buried underground 20, 25 feet and more. The earth loads bearing down on pipe and tending to crush it at these depths may reach relatively high values. In determining the

choice of pipe, the loading must be carefully calculated to assure that adequate crushing strength is obtained.

As has been mentioned above, Transite Pipe consists of intimately mixed asbestos fibres and cement which have been consolidated under high pressure to develop unusually high tensional, flexural and crushing strength. Uniformity of the material is further checked at the factory by subjecting each length to an hydraulic pressure test calculated to check the pipe to the equivalent earth loading stresses for which it is recommended.

Crushing loads imposed upon sewer pipe are dependent upon a variety of conditions. Foremost among these are type of soil, width of trench, and depth of overburden. These can be evaluated and the strength required of the pipe can be computed. The resistance of the pipe to this crushing load will depend in part upon the type of bedding furnished. Frequently, concrete cradling or encasement is necessary to furnish greater support, and to develop higher resistance against crushing.

The use of Transite Pipe often eliminates the need for cradling. For instance, a recent installation in an industrial city called for Transite Pipe installed in a soil foundation despite the fact that the pipe was laid only 30 inches beneath a heavily trafficked street. In another installation, the pipe was laid, without cradling, across swamp lands, covered with a 20 foot backfill and topped with a roadway which the town took the opportunity of constructing as a convenient means of transportation across the area.

Perhaps the greatest economy which Transite Pipe can offer its user is directly attributable to high flow characteristics. It has already been mentioned that the pipe is made on polished steel mandrels which impart to the interior of the pipe a smooth, unbroken surface. It is this surface which is responsible for the high flows obtainable.

The most familiar sewer pipe flow coefficient used among designing engineers is probably the Kutter's "n" appearing in the Kutter's formula. Depending upon the velocity of flow and diameter of pipe, Transite offers values as low as "n" = 0.009. Equally important in maintaining high flow capacity is the fact that the value of "n" for this material cannot be reduced by tuberculation. In pressure lines, pumping costs are reduced to the point where, often, the savings effected more than pay for the cost of the material. In some instances, the engineer finds it possible to use a smaller diameter pipe with no increase in pumping costs.

In gravity lines, savings are even more striking. Lines can be laid to flatter grades, eliminating deep trenches and effecting substantial economies in the cost of excavation. Calculations on a project contemplated at this time and involving $3,300 worth of pipe show a saving of approximately $8,000 on these counts. This was affected by reducing the contemplated amount of soil and rock excavation and eliminating the need for a pumping station to raise the sewage to the elevation of the treatment plant. Incidentally, these savings do not include the economy effected through speedier installation, reduction in labor, elimination of flush tanks, lower maintenance, etc.

In another instance, it was desired to connect a system of laterals to an intercepter located at a distance of 1200′. The grades between these two points were already established and such that the flow characteristics of this

pipe enabled it to meet the grade of the sewer at the lower end of the line without the repumping originally contemplated.

Where it may not be desirable to take advantage of flatter gradients, appreciable saving can often be made by choosing a smaller diameter pipe than ordinarily required. Sometimes it is more economical to combine the advantages of reduced gradients and smaller diameter pipe.

Although sewage may be substantially neutral chemically speaking, it is very often alkaline or aciduous, varying widely in degree of corrosivity. The material chosen for sewer pipe must, of necessity, be resistant to corrosion. Transite is of an unusually impregnable and resistant composition. One of the steps involved in the manufacture of the pipe has converted lime ordinarily found free in cement products into a group of stable and relatively inert lime-silicates highly resistant to the attack of sewage. This has been demonstrated by Underwriters' Laboratories' tests, which show the material to possess only a fraction of the alkalinity ordinarily encountered in cement products. Leaching tests on Transite Pipe are used to determine the stability of cement products and to further demonstrate the relative inertness of this material.

It is not necessary, however, to turn to laboratory tests to be convinced of the ability of the material to withstand the attack of corrosion. Sewer Pipe installations in all types of soil—alkaline, aciduous, cinderfill, salt marsh, sea water — have demonstrated that the material is well suited for use in sewerage systems. For several years, Transite Pipe has been used in scores of mines where corrosive acid-bearing waters must be drained. Installations of Transite Pipe are effectively handling these flows after several years' service. Some of these waters have been known to dissolve metal in a matter of a few days. Numerous industries employing process lines carrying corrosive fluids have been attracted to Transite Pipe because it offers durability with efficient hydraulic characteristics.

In addition to many eastern installations, Transite Pipe has been used on several sewer projects in the West such as the one in San Francisco's Golden Gate Park. The American Potash and Chemical Co. at Trona, California have a 24″ Industrial line where the exterior as well as interior conditions are chemically aggressive. This company uses Transite Pipe for various purposes, primarily because of the aggressive surroundings. The Federal Government departments including the War Department at Hickam Field, Honolulu, and Camp Ord near Salinas, California, the National Park Service at Grand Canyon and Casa Grande National Monument, Arizona, and the Farm Security Administration at Westley, California, are using Transite Sewer Pipe. The State of California is at present installing a Transite Sewer line at Agnew Institution.

I wish to thank you for the opportunity and privilege of appearing before you at this, my first time, in attendance at your conference. It indeed has been highly interesting and educational.

AMERCOAT

A Protective Coating for Concrete

By **Ernest F. Bent**

Vice-President American Concrete and Steel Pipe Company

On receipt of the first request by the Secretary for this presentation, it was felt somewhat premature to make a statement upon the development of this material which is still under way with some favorable and some questionable test results. However on the further request that a progress report on a material of such considerable concern to many engineers would be helpful, the following is presented.

Although not the case in normal collecting sewage lines, in some outfalls and treatment works the sewage becomes septic, caused by extreme length in sewage flow, high sulphate content of water, climatic conditions, or slow velocity, and forms above the flow a weak acid that is corrosive to untreated concrete. The development of a surface treatment for concrete that will protect it from such corrosion being urgently needed, this company has in the past several years tested or observed tests of every material known by them to meet this problem, but none has stood up under the most severe exposures.

Therefore, four years ago an industrial chemist was employed to attempt the development of an adequate coating at reasonable cost. The result of his research is a product trade-named "AMERCOAT," the bases of which are some of the plastics or synthetic resins that are today revolutionizing many industries. Finely graded inert materials are added to give the finished coating body. This coating, when applied, bonds tightly to both concrete and steel, is inert to acids and gases and is impermeable. It dries into a hard, tough, smooth and abrasion-resistant surface. Laboratory exposures of this material for periods of several years in 10 to 20% sulfuric, nitric, hydrochloric and other acids, are entirely unaffected.

Various exposures have been made for approximately two years in sewers and places such as at the Hyperion Screening Plant of Los Angeles City where septic conditions are so violent that dense concrete is seriously corroded in a few months. While the material has resisted exposure to most of these severe conditions well, some have somewhat softened or blistered. Further tests are under way.

The company believes that today "Amercoat" is the best of the known materials for this purpose and that the results to date are so encouraging that with further adaption of the ingredients and methods of application, it has the promise of being a completely satisfactory answer to this problem.

UNGLAZED CLAY PIPE

By **H. W. Jewell, Chief Engineer Pacific Clay Products**

A discussion of Clay products usually begins with a description of thos made by the Egyptians or some other ancients. That those products hav withstood the ravages of time is well known to all of you. The compara tively simple products of the past bear significance at this time only insofa as the permanence of the material is concerned. The clays used were of th same general character as those of today. The products of course were forme by hand but the fundamental principle of that ancient process—namely, th bonding together of inert materials by heat, stands today. Modern civiliza tion has changed this process only in degree. Today it is known to you as th "Process of Vitrification." A definition of vitrification is that process o heating clay products to such a temperature that the different grains makin up the body fuse together. It is apparent from this that the quality of a cla product is a function of the degree of vitrification. This is particularly tru of those requiring strength, chemical resistance, impermeability and perma nence under ever changing conditions of temperature, water saturation, freez ing and thawing. These are essentially the requirements for pipe, liners manhole brick and segment blocks used in the construction of sanitary sewer and other underground structures.

It was early recognized by the clay industry that some means of insurin and indicating vitrification was important both to the industry and the buyer The early clay manufacturer conceived the idea of adding rock salt to th fire at temperatures which cause it to volatilize and settle over the ware forming a glassy like surface. This process is known to you as salt glazing It has served the industry well and any product which you see that has beer salt glazed you can rest assured has a high degree of vitrification. The Pacifi Clay manufactures salt glazed products; however, in recent years the com pany has conducted considerable research on clay materials that matur beyond the range of salt glazing temperatures, and also on a method of glaz ing that permits the application of the glaze to the ware before firing.

The manufacturing of the unglazed pipe was commenced in 1930. Lack of glazing gave rise to many engineering questions regarding chemical re sistance, strength, imperviousness, bonding and flow characteristics. As man ufacturers, we realized the importance of these questions to engineers, and have conducted tests to answer these questions and to prove the high quality of unglazed pipe. Reference throughout the test series is made to Vitro-Dur which is the trade name of unglazed pipe as manufactured by Pacific Cla Products.

A brief outline of these tests which are included in detail in this paper follows:

1. A Petrographic analysis of thin sections of Vitro-Dur pipe to show the extent of the fusion of the shale and quartz.
2. Comparative chemical tests on Vitro-Dur and unglazed chemical stoneware including both acid and alkali tests.
3. Modulus of Rupture tests on clay bars showing the relation o vitrification to strength and porosity.

4. Strength requirements of extra strength pipe in Southern California.

5. Shear tests on unglazed brickettes bonded together with chemical setting sodium silicate cement and tested after one week of emersion in a 10% solution of sulphuric acid.

6. Flow tests to indicate that no loss in carrying capacity is realized due to lack of glaze.

To date there are more than 150 miles of unglazed pipe in Services in Southern California, ranging in size from 4 to 36 inches in diameter and from 3 to 6 feet in unit length.

Recently 6 ft. 42 inch pipes have been successfully manufactured. Six foot pipes are made without bells, a separate reinforced concrete collar being used to form the joint. Chemical protection is provided by the use of sodium silicate cements or sulphur silica compounds positioned between the butt ends of the pipes. The outside joint is finished with Portland Cement which can be placed in the usual manner, or where pressure tight joints are required it may be hand caulked in the same manner as a water main joint.

Other developments in unglazed products include liners, segment blocks and 4 inch diameter 5 ft. length house connection pipe. These products are partly glazed by applying the glaze materials before placing the ware in the kilns for firing. This method is not new to the ceramic industry. It is the same process that is used to glaze electrical insulators, bathroom tile, and other products requiring imperviousness. Its application to pipes, liners and electrical conduits has important bearing on those engineering problems involving corrosion, friction, fowling and water tightness.

The liners are glazed on the inside face only, making them more impervious to the penetration of gas and acid water. Four inch diameter five foot pipes are glazed on the inside only. Considerable research has been done on this type product aimed primarily at the development of a root-proof line. The research included the joint and various types of jointing materials, and has been conducted over the past five years in cooperation with Los Angeles City and County engineers. The pipe and joint which is marketed under the trade name "Ceramicweld" has been extensively tested in the laboratory, the root plot, and in actual service. We believe it to be the answer to the problem of root-proofing a sanitary sewer line.

There are several other products under investigation where Vitro-Dur and part glazing will make it possible for the clay industry to meet still more rigid requirements. Some of these are air pressure syphons, chemical equipment, water pressure pipe and high voltage electric conduit.

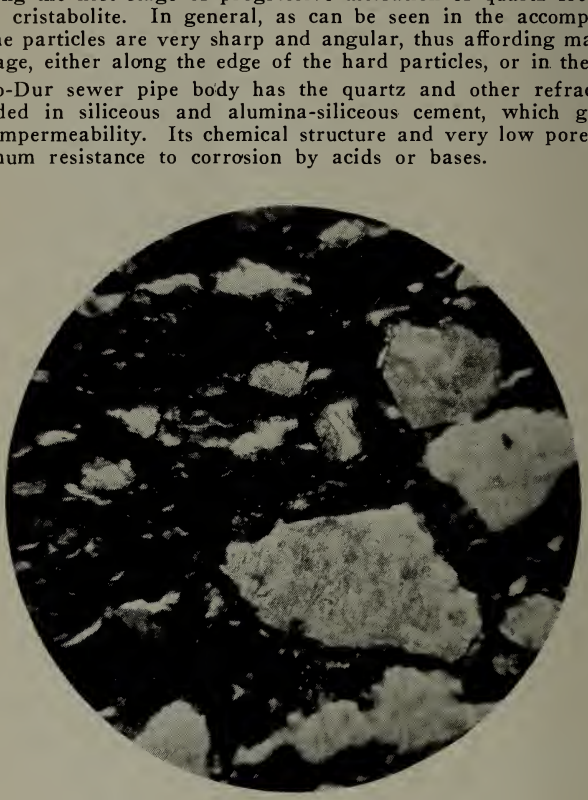
Before closing I wish to impress upon you the importance of rigid testing requirements and adequate sampling. It is only through this that one can assure himself that he is getting what he specifies. Insofar as pipe testing is concerned the specifications of the A. S. T. M. provide adequate safeguards for pipes of A. S. T. M. strength except that no hydrostatic pressure test is required. Southern California Specifications require more sampling and a hydrostatic pressure test, the latter to precede the crushing test. It is felt that this adds a measure of security to the pipe requirements.

TEST No. 1

Petrographic Analysis of Vitro-Dur Pipe Body

This is a very tight, firm, tough and compact body. It is well vitrified and resists grinding stresses in the preparation of the .0012 inch thick section exceedingly well. Fusion of the matrix around the particles of quartz and shale is well developed. The material within the body shows the effect of firing to an adequately high temperature in that some of the quartz particles are slightly altered around the edges, this being the first stage of progressive alteration of quartz from its original alpha form to cristabolite. In general, as can be seen in the accompanying photomicrograph, the particles are very sharp and angular, thus affording maximum resistance to breakage, either along the edge of the hard particles, or in the matrix itself.

The Vitro-Dur sewer pipe body has the quartz and other refractory particles tightly imbedded in siliceous and alumina-siliceous cement, which gives it added strength and impermeability. Its chemical structure and very low pore space content affords maximum resistance to corrosion by acids or bases.



VITRO-DUR PIPE BODY
Magnified Sixty-five Times

TEST No. 2

Comparative Chemical Tests on Vitro-Dur Pipe and Chemical Stoneware Pipe

Initial Porosity

The initial porosity of the various samples was obtained by first thoroughly scrubbing the samples to free of any extraneous matter, then thoroughly dried by applying heat to determine the initial weight. The samples were then submerged in tap water for 24 hours, allowed to drain for one minute and then weighed.

Preparation for Test

The samples where then thoroughly dried again before subjecting them to their respective tests. This would permit of a greater penetration.

Final Porosity

After the samples were removed from their respective tests they were thoroughly washed in cold running water for several hours, then boiled in water for several hours. The pieces were then heated over night and the weight determined. After this the samples were again submerged in tap water for a period of 24 hours and the final porosity obtained.

The Chlorine Gas Tests

In the case of the Vitro-Dur samples, a small amount of residual chlorine appears to have been retained in the body. This was evident by placing the samples in a separate beaker containing distilled water, adding potassium, iodine and starch. The beakers were then heated. If any chlorine is present a chemical replacement would occur. The resulting products being potassium chloride and free iodine. This iodine would impart a blue coloring to the starch. The amount in each case, however, was very small, the blue color disappearing with one or two drops of N/10 sodium thiosulphate.

CHLORINE GAS TEST

Samples were placed in a tank and air was forced out by the introduction of chlorine gas. While the anticipated service conditions of the piper are 4# of chlorine gas to 100 gallons of water, these tests were made with a 100% concentration of chlorine gas. This is many times more severe than that which will be encountered in actual service. The results of the test were as follows:

Vitro-Dur Pipe

Porosity Initial	*Weight Initial*	*Weight After 10 Day*	*Weight After 38 Day*	*Loss or Gain 10 Day*	*Loss or Gain 38 Day*
4.90	312.3	313.0	313.5	+0.7	+1.2
4.62	271.3	271.0	271.7	—0.3	+ .4
4.58	294.8	294.8	295.0	0.0	+ .2
4.75	347.5	347.5	348.8	0.0	+1.3

Chemical Stoneware Pipe

.97	320.0	320.0	320.5	0.0	+0.5
.82	269.0	269.0	269.5	0.0	+0.5
1.17	289.7	290.0	290.0	+0.3	+0.3
.91	354.5	355.0	355.0	+0.5	+0.5

SULPHURIC ACID TESTS

Vitro-Dur Pipe

H_2SO_4	*Porosity Initial*	
100%	4.44	After 10 days no change in physical appearance.
100%	4.32	" " " " " " " "
50%	4.08	" " " " " " " "
50%	4.38	" " " " " " " "
25%	4.25	" " " " " " " "
25%	4.40	" " " " " " " "

Chemical Stoneware Pipe

100%	.12	After 10 days no change in physical appearance.
50%	.33	" " " " " " " "
25%	1.14	" " " " " " " "

SULPHURIC ACID TESTS

NOTE: It is impractical to obtain final weights of samples treated in sulphuri acid for the reason that the acid combines with the body of the sample in such a man ner that it cannot be freed from the individual samples under conditions which woul be comparable.

NITRIC ACID TESTS

Vitro-Dur Pipe

	Porosity		
HNO_3	*Initial*	*Final*	
60%	4.56	4.80	No loss in weight was evident.
60%	4.68	4.62	" " " " " "
35%	4.60	4.82	" " " " " "
35%	4.88	5.00	" " " " " "

Chemical Stoneware Pipe

60%	.89	1.12	No loss in weight was evident.
35%	1.02	1.11	" " " " " "

HYDROCHLORIC ACID TESTS

Vitro-Dur Pipe

	Porosity		
HCL	*Initial*	*Final*	
35%	4.32	4.12	No loss in weight was evident.
35%	4.68	4.56	" " " " " "

Chemical Stoneware Pipe

35%	.97	.56	No loss in weight was evident.

In addition to Acid Tests pipe samples were tested in concentrated solutions of sodium hydroxide and no loss of weight was noted.

TEST No. 3

Modulus of Rupture Tests on Unglazed Bars 8″ x 1″ x 1″

Clay Products Ass'n Industrial Fellowship No. 3A and 13—Jan. 1925

Shale Clay

Temperature	*Modulus Lbs. Sq. In.*	*Apparent Porosity*
1850°F	2549	21.5
1922°F	3065	15.6
1994°F	3951	4.93
2066°F	4195	2.46
2174°F	4033	.61

Fire Clay

1958°F	1483	24.3
2102°F	1976	20.9
2174°F	2410	13.8
2282°F	2997	5.02
2354°F	3361	4.02
2426°F	3237	3.96

TEST No. 4

Structural Tests

The specifications for Extra Strength Pipe in Southern California permit the

use of unglazed pipe. The following is a table of comparison between A. S. T. M. and Southern California requirements:

A. S. T. M.		*Southern California Extra Strength*
6	1430	2020 lb. per ft., sand bearing.
8	1430	2450
10	1570	2930
12	1710	3350
15	1960	3990
18	2200	4680
21	2590	5400
24	3070	5880
27	3370	6540
30	3690	7140
33	3930	7790
36	4400	8400

To meet these increased strengths with Vitro-Dur Pipe the wall thickness was increased from $\frac{1}{16}$ to $\frac{1}{2}$ inch on sizes 6 to 36 inch respectively.

A comparison of the Modulus of Rupture (Iowa State College Formula) between 3'-36" Std. Str. Pipe as manufactured in 1930 and 3'-36" Extra Str. Pipe manufactured in 1938 is 1538# sq. in. and 1950# sq. in. respectively.

TEST No. 5

January 4, 1938.

Pacific Clay Products Co.,
306 West Ave. 26,
Los Angeles, California.

Report of Tests

In compliance with your request wherein you asked us to make shear tests on samples submitted to our laboratory, we submit the following results:

Date made: December 22, 1937.
Date placed in 10% solution of Sulphuric Acid: December 27, 1937.
Date tested: January 3, 1938.
Bonding material: Penchlor. Tested in Double Shear.

Lab. No.	*Mark*	*Total Load in Pounds*	*Single Shear Area in Sq. In.*	*Single Shear in Lbs. per Sq. In.*
P49015	5A	3410	16	213.13
P49016	6A	3400	16	212.50
P49017	7A	2100	16	131.25
P49018	8A	3730	16	233.13
P49019	9A	1800	16	112.50
	Average	2888		180.50

Date made: December 23, 1937.
Date placed in 10% solution of Sulphuric Acid: December 27, 1937.
Date tested: January 3, 1938.
Bonding material: Vitrex. Tested in Double Shear.

P49020	5B	3820	16	238.75
P49021	6B	3790	16	236.88
P49022	7B	3180	16	198.75
P49023	8B	3140	16	196.25
P49024	9B	3100	16	193.75
	Average	3406		212.88

Respectfully submitted,
(Signed) SMITH-EMERY CO.,
Inspecting and Testing Engineers,
D. F. R.

(Seal)

TEST No. 6

Flow Tests

Conducted under Supervision of Franklin Thomas, Civil and Hydraulic Engineer

Quantity Measurements

The quantity of water realized for the duration of any test was only a matter of calculation of the sump capacity. For the purpose of expediting these calculations a table of cubic feet contents at each inch of depth was made for both of the sumps. The sump was thoroughly tested for leakage and for all practical purposes was water tight. The sump was filled to capacity and allowed to stand 48 hours during which time no appreciable fall was noted.

The quantity data obtained shows a greater volume of water obtained through the Vitro-Dur pipe than through the Glazed or Cement line. As shown by the accompanying data this increase is consistent between the Vitro-Dur and cement concrete line averaging over 6% at each depth. The increase over glazed is only slight and for all practical purposes can be considered the same as Vitro-Dur.

Data on Quantity of Water Cubic Feet per Second Determined by Actual Sump Measurement

Depth of Water in Inlet Box	*Run Number*	*Cement*	*Vitro-Dur*	*Glazed*
2"	#1	.0659	.0694	.0654
	2	.0659	.0699	.0669
	3	.0654	.0699	.0654
Average		.0657	.0697	.0659
3"	#1	.1447	.1487	.1467
	2	.1447	.1507	.1487
	3	.1428	.1507	.1444
Average		.1437	.15	.1466
4"	#1	.2498	.2627	.2557
	2	.2498	.2642	.2557
	3	.2574	.2515	
Average		.2485	.2614	.2543
6"	#1	.4980	.5232	.5227
	2	.5084	.5211	.5148
	3	.5001	.5211	.5148
Average		.5021	.5218	.5174
Full Flow	#1	.7775	.8336	.8336
	2	.7775	.8336	.8405
	3	.7775	.8300	.8321
Average		.7775	.8324	.8354

Velocity Measurements

The velocity data has been determined by two methods. The color method and the quantity area method.

The color method consists of dropping a known quantity of ink or dye into the flow at the inlet and recording the mean of the time it first and last appeared at the outlet. The velocities by the quantity area method are determined by dividing the quantity of water per unit of time by the area of the water cross section for that depth.

Both methods show a consistently higher velocity for the Vitro-Dur line.

The velocities as determined by the color method are maximum or center velocities and are substantially higher than those obtained by the area method, which are mean velocities. Accepted formulae generally used in the computation of velocities in circular pipes usually establish the velocities at half depth as approximately equal to full depth. This is substantiated by the color method data obtained from these tests.

Data on Velocity of Water Lineal Feet per Second as Computed by Area Method

Depth of Water in Inlet Box	*Run Number*	QUANTITY AREA OF CROSS SECTION *Cement*	*Vitro-Dur*	*Glazed*
2″	#1	.975	1.022	.956
	2	.975	1.029	.978
	3	.967	1.029	.956
Average		.97	1.027	.963
3″	#1	1.222	1.250	1.220
	2	1.222	1.266	1.237
	3	1.205	1.266	1.201
Average		1.216	1.261	1.219
4″	#1	1.441	1.514	1.457
	2	1.441	1.523	1.457
	3	1.425	1.484	1.433
Average		1.435	1.507	1.449
6″	#1	1.801	1.878	1.848
	2	1.839	1.870	1.820
	3	1.809	1.870	1.820
Average		1.816	1.873	1.829
Full Flow	#1	2.299	2.426	2.352
	2	2.299	2.426	2.371
	3	2.299	2.416	2.347
Average		2.299	2.419	2.357

ASBESTOS BONDED CORRUGATED PIPE

By **L. W. Wyman**
Chief Engineer California Corrugated Culvert Co.

To understand the status of corrugated metal pipe in the field of sanitary sewerage, it is necessary to review briefly the history of the product in highway and railroad use. The structural or design merits of the product are the same in all three fields and account for its remarkable success during the 40 or more years since its introduction.

The corrugated culvert was invented in Crawfordsville, Indiana, in 1896. Considered at first as a curiosity, it soon demonstrated its title to a place in the field of highway drainage. Properly installed it showed itself capable of adequately carrying the loads of fill and traffic, and by 1906 this form of culvert came into very common use under the rural roads of the Middle West.

The remarkable qualities of corrugated pipe are strength and resiliency. The corrugated form multiplies its resistance to external strains several times over that of smooth pipe of the same gage and diameter and also gives it flexibility or toughness which enables it to withstand unevenly settling foundations, frost action, and the shocks and jars of traffic, even when placed close to the road surface.

The production of corrugated culverts expanded rapidly in the following decades. They were employed largely on railroads and in city streets, as well as on rural highways. By 1920 the corrugated pipe had come to be practically the standard highway culvert all over the country.

About 1923 various state highway departments began "looking under their roads." In these extensive investigations the conditions and indicated service lives of various culvert materials were carefully tabulated and averages obtained. The results showed corrugated pipe was by and large giving a very excellent account of itself. On the whole the highway surface drainage of the country was being successfully cared for by this comparatively new material.

In 1925 the Highway Department of the State of California began a most thorough and painstaking investigation of corrugated and other culverts in the various highway districts of the state. Actual conditions found were carefully recorded and anticipated service lives were estimated. Those for corrugated pipe turned out to be well over half a century. Such deterioration as was found after ten to fifteen years of service had resulted from erosion and corrosion, and it is the remarkable fact that among 4250 corrugated culverts examined there was not one structural failure. The structural performance of all types of culverts caused the universities and the research bodies of the railroads to investigate the reason why.

The A. R. E. A. Culvert Investigation In 1925 and 1926 the American Railway Engineering Association conducted a noteworthy investigation of the loads to which flexible and rigid culverts are subjected. Preliminary investigations were conducted on different types of pipe under shallow earth covers when subjected to heavy surface loadings by a machine devised for that purpose. Finally installations were made under a railroad at Farina, Illinois, where test pipes of the different types were installed under fills up to 35 feet high. The corrugated pipes tested ranged in diameters from 18 inches up to 48 inches and from No. 16 to No. 8 gage. Deflections and external pressures were accurately determined and recorded. In no instance did any of the corrugated pipes show a condition approaching failure.

The findings of the Committee were set forth in its Bulletin No. 284, "Culvert Load Determination." Briefly speaking the results obtained by the Committee were that corrugated pipe, because of its flexibility, is subjected to loads from the fills over it of much less than their actual weight, whereas rigid culvert structures are called upon to endure pressures of approximately 1½ times the weight of the material over them.

Investigations at State Universities Iowa State College, under the leadership of Dean Anson Marston, had made notable investigations of the pressures on pipes in ditches and embankments for a number of years. It was Dean Marston's explanation of the widely varying pressures on flexible and on rigid structures in embankments that was adopted by the Committee of the American Railway Engineering Association in making its epochal report, "Culvert Load Determination." The University went on with further investigations and experiments which served to confirm and clarify the earlier statements. These are embodied in Bulletin No. 96 of the Iowa State College, "The Theory of External Loads on Closed Conduits in the Light of the Latest Experiments," by Dean Anson Marston, and several other bulletins by associated investigators.

The University of North Carolina, through Professor G. M. Braune,

carried the study further by installing a number of 30″ pipes ranging from very flexible to completely rigid under a 12-foot fill, and established the fact that the pressures on the tops of these cylinders varied in inverse proportion to their flexibility from approximately 1800 pounds per lineal foot for the most flexible (smooth iron) up to 5700 pounds per lineal foot for the solid concrete plug. The weight of the fill over the pipes was 3190 pounds per lineal foot.

The reasons for this interesting state of affairs as given by Dean Marston and others are, briefly, as follows: All earth and gravel fills tend to settle after placing, and this settlement is in proportion to their height. The heights of the two columns at the sides of a buried cylinder are, of course, greater by the cylinder's diameter than the height of the column directly over it. Therefore, they tend to settle more. In so doing they drag down the prism of earth directly over the pipe and greatly increase the pressure on the top of the cylinder.

When the pipe is flexible (as, for instance, a corrugated pipe) it deflects slightly under the pressure of the embankment and by so doing it causes the column of earth above the pipe to settle more than the columns of earth at the sides. This is the reverse of what happens in the case of a rigid structure and the column of earth above the pipe transfers a portion of its weight by friction to the columns at the sides, causing the load on the pipe to be only a portion of the weight of the material directly over it.

Service Experience All this was very encouraging to the makers and users of corrugated pipe. However, the investigations in the field had clearly shown that the inverts of all types of culverts showed more wear than the balance of the structures. Where the ground surrounding a corrugated pipe or the water which it carried was actively corrosive, as in salt marshes, alkali deserts, etc., rusting was often comparatively rapid; and where the water contained quantities of sand, gravel or stones—especially if it ran at high velocity—erosion of the invert or lower third of the interior was sometimes in evidence. In fact, nearly all the deterioration of corrugated culverts in service seems to be confined to this portion. These were the conditions actually found, and they pointed unmistakably to reinforcement of this section as the practical remedy.

Paved Invert Pipe About 1923 the Armco research laboratory took up the problem of protection in the bottom of corrugated metal pipe so as to secure a "balanced design" — an advantage possessed by no other type of pipe. Among the various methods tried to reinforce the bottom were: extra heavy galvanizing, a heavier metal bottom section, cement mortar, paints, vitreous enamel, and various bituminous materials. Of these, bituminous materials gave the best results. More than 300 different kinds were tested before a special grade was finally developed, which not only assures maximum resistance to erosion, but also withstands severe temperature changes and the corrosive actions of acids and alkalies.

Paved Invert Pipe was introduced in 1925—the same corrugated design —the same galvanized high quality iron—plus a thick bituminous pavement *entirely filling and covering the corrugations in the bottom of the pipe.*

Five Million Feet in Service During the past 12 years more than five million feet of Armco Paved Invert Pipe has been installed for sewer and drainage purposes. Installations ranging in diameter from 12 to 84 inches are serving satisfactorily in more than 1,000 cities—including the largest city in the United States. A large number of these installations have been made by city maintenance departments where, because of soft foundations, rigid conduits were difficult to maintain. In addition a considerable footage of Paved Invert Pipe had been used for outfall sewers, where foundation conditions would have required expensive piling or cradles had short sectional pipe been used.

Based on its dependable performance under these severe conditions, municipal engineers and officials began to realize that Paved Invert, Corrugated Pipe is a valuable recourse in many of their sewer problems because of its strength, flexibility, light weight, long lengths and positive joints.

What Inspections Show Inspections of 20,000 feet of Armco Paved Invert sewers—from 6 to 12 years old—show that, in most cases, the thick bituminous pavements have completely stopped invert wear and are still giving full protection to the underlying metal.

This means that the bituminous pavements have already added 12 years to the 30-year service record of plain galvanized Armco Pipe, with the expectation of many years of service in the future.

Paving Methods The first invert pavements were applied to corrugated pipe by dipping in horizontal tanks of hot bitumen and allowing just enough bitumen to remain in the bottom to form the pavement. For larger diameter pipes, several dippings are necessary adequately to cover the invert.

Another method which is now becoming general is that of using a premolded or mat-type pavement. By this method a thick bituminous slab of any desired width is applied to the bottom of the pipe without the necessity of repeated dipping and turning. It is firmly bonded to the pipe and is proving highly successful.

Resistance to Erosion To provide a quick method for testing the erosion resistance of bituminous paved and coated pipe, the Connecticut State Highway Department developed a special type of tumbling machine. This device consists of a hollow cylinder into which is placed a specimen of pipe, together with 3 gallons of water and 50 pounds of sharp brickbats. After closing both ends of the cylinder, it is then rotated so that the sharp bricks slide along the smooth pavement in the bottom, and then along the top. This is continued for the number of hours specified for the test.

Some state highway departments have specified that the bituminous pavement in the bottom of the pipe must be able to withstand the erosion tests for ten 5-hour periods with new brickbats for each period. However, the smooth pavement in Armco Pipe can take it three or four times this long. When a 10 per cent soap solution instead of ordinary tap water is used in this test, the same results are produced. This indicates that the special bitumen used on Armco Pipe is not affected by soapy water.

Asbestos Bonded Corrugated Pipe During the 12 years Armco Paved Pipe has been on the market, Armco research engineers have conducted

extensive field tests and have also observed the tests of independent investigators working in the field of pipe coatings. Although this research has failed so far to discover a more satisfactory material for paving and coating corrugated pipe than the one above described, it has resulted in the development of a special bonding process that assures greatly increased permanence.

This new process may be described briefly as follows:

As the flat sheets of culvert metal emerge from the galvanizing rolls, a layer of *asbestos felt* is pressed firmly into the molten zinc coating. Millions of asbestos fibers thus become partially embedded in the zinc as it hardens. The sheets are then passed through specially designed equipment which thoroughly saturates the porous mass of fibers remaining on the surface. After the excess saturant has been squeezed out, the sheets are allowed to cool. Then they are inspected, corrugated and made ready for shipment to the culvert factories.

From this point on these special bonded sheets are formed into corrugated pipe and paved and coated in the usual way. In the dipping tank the hot bitumen naturally melts together with the bituminous saturant on the pipe, forming an integral coating and paving. This protective coating and pavement in turn are permanently bonded to the pipe by means of the asbestos fibers embedded in the galvanized metal.

Besides providing an excellent bond between coating and metal, asbestos bonding actually widens the plastic range of the bituminous material—as much as 52 per cent. This gives an added factor of safety, especially when the pipe must be handled or stored during extreme temperatures. Asbestos, itself, is an inert mineral product—rot-proof and non-deteriorating.

Withstands Heat To test heat resistance, specimens of Asbestos Bonded Pipe are placed upright in an electric oven and left in that position for four hours at a temperature of 180° F. At the end of this period, even the thick bituminous pavement (which is much thicker and heavier than the coating) flows less than a quarter of an inch. This temperature is much hotter than the maximum field temperatures.

Withstands Cold To prove the ability of the bituminous material to withstand shock in cold weather, coated half-sections of Asbestos Bonded Pipe were placed inside a refrigerator and frozen to 0° F. Immediately afterward, a solid steel ball weighing 1.67 pounds was dropped onto each frozen sample from a height of 7½ feet—without spalling or cracking the bituminous material on the inside of the specimen.

The Effect of Sewer Gases Our research department tells us that if sewers are designed and constructed to maintain velocities of not less than 2½ feet per second in combined sewers, and not less than 2 feet per second in separate sewers, the chief reason for the formation of hydrogen sulphide gas will be eliminated. As an added factor of safety, Asbestos Bonded Pipe is fully coated with a special bituminous material applied in such a positive manner that it will remain in place in storage, in handling and in service.

The investigators report that this special material has been used on numerous combined and sanitary sewer installations for 12 years and with

complete success in resisting the action of hydrogen sulphide or other sewer gases.

Of course, if damage to the coating through scratching or scraping occurs during handling and installing, any such scars should be healed by the application of hot bituminous material before the pipes are covered.

A Practical Construction Material The physical qualities of corrugated pipe especially adapt it to conditions of unstable and settling foundations such as are frequently encountered in outfall sewer installations, and its ability to withstand, without injury, the shocks and jars of traffic when placed near the surface and the expansion and contraction caused by freezing, make it practical where installations of rigid materials might be short lived.

With the added protection of invert paving and asbestos bonding, it presents an adequate resistance to erosion and corrosion. As far as we know all the installations of this material are completely successful, and the American Rolling Mill Company believes it has demonstrated its right to favorable consideration in the field of sanitary engineering.

NOTES

Selected from the Correspondence of the Secretary

Seldom have the members of this Association shown such an intent interest in the message brought to us by a guest speaker than in the words of Mr. Francis T. Letchfield. Because of the warm reception given Mr. Letchfield's address, it has been published in this number of the Journal for our less fortunate members who could not attend the Visalia meeting and to refresh the memory of those present.

The Tenth Anniversary Volume of the Federation has received extremely favorable comment from many of our members and would be an excellent addition to your library. Copies may be obtained from Wm. W. Buffum, Business Manager, Sewage Work Journal, 654 Madison Avenue, New York City, N. Y., at $2.50 per copy.

The State of California now has a Sewer Revenue Bond Act passed by the last session of the Legislature which became law June 13, 1939. It is predicted this act will stimulate sewer and treatment plant construction in California. Similar laws are in existance in 38 other states and are being successfully operated.

The New England Sewage Works Association at their Spring Meeting May 15, 1939 at the Springfield Country Club released two innovations we might try sometime, a Question Box conducted by Morris M. Cohn and a Golf Match.

The Pennsylvania Sewage Works Association wound up their Thirteenth Annual Conference, a particularly full session covering the field of sewage treatments from Finance through many of the Trade Wastes to Good Housekeeping, Wednesday afternoon June 28, 1939, with Golf, Baseball and Fishing.

Our compliments go to the Arizona Water and Sewage Works Association upon the excellent bulletin they are publishing.

Up the Ladder to Fame

Just about the time we have become acquainted with Rolf Eliasson, Sanitary Engineer for the Dorr Company, he announces his departure to become Assistant Professor of Sanitary Engineering at Armour Institute. We are sorry to lose you, Rolf, but happy to send another of our members up the ladder to fame.

Keeno Fraschina, who recently became a member of this Association, has assumed the duties of Assistant Superintendent and Chemist at the San Francisco Richmond-Sunset Sewage Treatment Plant. He was formerly employed by the San Francisco Water Department as a Chemist under G. E. Arnold. Good work Jerry, we are glad to see your boys moving up.

R. R. Sotter, another new member of this Association, has recently been appointed Chief Operating Engineer at the San Francisco Richmond-Sunset Treatment Plant. Mr. Sotter was formerly Chief Engineer on the Grace Steamship Line.

Marvin Anaya has just completed plans for a sewage disposal plant at the Hassler Health Home under the direction of Professor Chas. Gilman Hyde.

Harvey F. Ludwig is now Water Purification Engineer for the San Francisco Water Department. Mr. Ludwig is a graduate of the University of California, Class of 1939 in Sanitary Engineering.

L. H. Chamberlain has departed for Chicago to become Manager Water Works Sales for the Crane Company. Mr. Chamberlain was formerly Manager of the Water Works Supply Co. in Los Angeles.

Mr. A. L. Frick is Acting President of the Arizona Sewage Works Association; pinch hitting for President Bernard McMorrow, who accepted a position with the Territorial Board of Health of Hawaii.

Accidents Will Happen

Even the designing engineer sometimes gets the wrong valve. Frank Currie was down at the Visalia Plant the evening before the Caravan giving the place the finishing touches. While standing in front of an emergency release valve directing the operator to open and close certain of the valves forming a battery which permit one sludge pump to do several jobs, the emergency valve decided to demonstrate its efficiency, giving Frank an unwanted shower of sludge.

Not to be outdone, John Clark went out to inspect a small Farm Security Plant a few miles from Visalia. The sludge pump was not working, which Johnnie, as a good engineer, decided to fix. Not satisfied to see it running, he opened a cock to see how well it was working, with disastrous results. All next day Johnnie moved slowly in Carl Beyer's trousers, Al Frick's shoes and other kind offerings.

A Perfect Host City

Mr. Ernest F. Bent arrived at Visalia during a rain storm, parked in a red zone in front of the Hotel, expecting to take his car to the garage im-

mediately after registering. Instead of so doing, he feasted with friends, reviewed his paper for the forthcoming day, and went to bed. Next morning he called at the desk and received a notice of violation of City Ordinance, stating that his car had been taken to the City Garage. Struck by his forgetfulness, he started for the City Hall, mustering all the excuses possible, but upon emerging from the Hotel found his car right where he left it; a note pinned to the steering wheel, "Thought you might want your car this morning, Sir!"



At the speakers table, Spring Conference Banquet at Visalia, left to right: H. D. Letchfield, speaker; President Alexander Bell, Mayor J. Pierce Gannon, H. G. Smith, First Vice President.













Plants visited on CSWA Spring Conference Caravan, April 15, 1939, were: 1—Visalia; 2—Delano; 3—Wasco; 4—[illegible]fter; 5—Bakersfield, under construction; 6—Tehachapi.



Candid camera shots of Spring Conference delegates at Visalia, April 14-15, 1939. (Photos by Claude Faw.)

CALIFORNIA SEWAGE WORKS ASSOCIATION
ROSTER OF MEMBERSHIP

(As of July 1, 1939)

Adams, W. K.
City Engineer
City Hall
Redding, Calif.

Adams, Allen A.
Treasurer-Eastern Manager
Sterling Electric Motors
5401 Telegraph Road
Los Angeles, Calif.

Albers, J. C.
City Engineer
Public Service Bldg.
120 No. Howard St.
Glendale, Calif.

Allen, William A.
Supt. Pasadena Disposal Plant
City Hall
Pasadena, Calif.

Arndt, Charles
Plumbing and Heating
110 Winston St.
Los Angeles, Calif.

American Cast Iron Pipe Co.
55 New Montgomery St.
San Francisco, Calif.
Attn.: W. R. Blair

Anaya, Marvin
Sanitary Engr. Designer
367 City Hall
San Francisco, Calif.

Arnold G. E.
Chief Water Purification Engr.
San Francisco Water Dept .
Millbrae, Calif.

Arrowhead Lime & Chemical Co.
1840 E. 25th St.
Los Angeles, Calif.
Attn.: Kennedy Ellsworth, Vice-Pres.

Banks, Harvey O.
Asst. Hyd. Engr.
Calif. State Div. of Water Resources
202 North Bushnell Ave.
Alhambra, Calif.

Banta, A. Perry
Asst. Engineer - L. A. Co. San. Dist.
110 South Broadway - 4th Floor
Los Angeles, Calif.

Barnard, Archer F.
Quinton, Code and Hill-
Leeds and Barnard
601 West 5th St. - Suite 905
Los Angeles, Calif.

Barstow Sanitary District
Box 418
Barstow, Calif.
Attn.: Wm. A. Knaggs, Secretary

Bates, John S.
Consulting Engineer
3134 Eton Ave.
Berkeley, Calif.

Batty, F. A.
Supt. of Sewers
745 City Hall
Los Angeles, Calif.

Beale, Ed.
Director, Bureau of Sanitary Engineering
City Hall
San Diego, Calif.

Beardsley, C. W.
Asst. Testing Engr.
Bureau of Standards
City of Los Angeles
1829 Park Drive
Los Angeles, Calif.

Bell, Alexander
Western Sales Manager
Wallace and Tiernan Company
171 Second Street
San Francisco, Calif.

Bell, R. H.
Operator
1300 Pennsylvania Ave.
Colton, Calif.

Benas, Ben
Sanitary Engineer
286 City Hall
San Francisco, Calif.

Bennett, S. G.
City Engineer
City Hall
Santa Paula, Calif.

Beyer, A. Carl
District Manager
Wallace and Tiernan Company
171 Second Street
San Francisco, Calif.

Bishop, H. N.
Consulting Civil Engineer
and City Engineer
Sunnyvale and Willow Glen
P. O. Box 333
Sunnyvale, Calif.

Blackman, J. W. B.
City Engineer-Director Public Service
City Hall
Long Beach, Calif.

Bowen, M. R.
City Engineer
205 North Greenleaf
Whittier, Calif.

Bowlus, Fred D.
Resident Engineer
Los Angeles County San. Dist.
110 South Broadway - 4th Floor
Los Angeles, Calif.

F. G. Boxall, Supt.
City Hall
Brea, Calif.

Brown, Kenneth W.
Sanitary Engineer
California Water Service Co.
829 North Monroe St.
Stockton, Calif.

Brown, Reuben F.
745 City Hall
Los Angeles, Calif.

Buck, J. H.
Superintendent of Streets
516 Santa Barbara St.
Santa Paula, Calif.

Buckingham, Earl M.
Draftsman, City of Oakland
96 Zinn Drive
Oakland, Calif.

Burnson, Blair I.
Asst. Sanitary Engineer
East Bay Municipal Utility Dist.
512—16th St.
Oakland, Calif.

Byxbee, J. F.
City Engineer
P. O. Box 450
Palo Alto, Calif.

Calif. Associated Concrete
Pipe Manufacturers
P. O. Box 914
Fresno, Calif.
Attn.: H. W. Chutter, President

California Institute of Technology
Pasadena, Calif.
Attn.: Franklin Thomas
Prof. of Civil Engineering

Castello, W. O.
Asst. Engr., Division of Water
112 City Hall
Sacramento, Calif.

Castro, Albert J. Jr.
Supt. of Sewage Disposal Plant
1303 Franklin St.
Santa Clara, Calif.

Chamberlain, L. H.
Manager
Water Works Sales, Crane Co.
836 So. Michigan Ave.
Chicago, Ill.

Chiarolla, Frank Vito
Student U. of C.
854 North Figueroa St.
Los Angeles, Calif.

Chitwood, C. S.
Water Supt. and Operator
Tehachapi, Calif.

Clark, J. C.
Chief Operator Sewage Plant
603—14th St.
Huntington Beach, Calif.

Clark, John A.
2644 Dwight Way
Berkeley, Calif.

Clark, N. and Sons
116 Natoma St.
San Francisco, Calif.
Attn.: Bradley W. Wyatt

Compton, C. R.—Office Engineer
L. A. County San. Districts
110 South Broadway—4th Floor
Los Angeles, Calif.

Cook, Lawrence H.
Chemical Engineer
Sec. Menlo Park San. District
Box 696
Menlo Park, Calif.

Cook, Max E.
Pacific Lumber Company
100 Bush Street
San Francisco, Calif.

Cooley, E. C.
Chicago Pump Co.
625 Market St.—Rialto Bldg.
San Francisco, Calif.

Cortelyou, H. P.
Deputy Engr. Bureau of Engr.
502 City Hall,
Los Angeles, Calif.

Crane, H. R.
Owner, Flexible Sewer Rod
Equipment Company
622 East 4th Street
Los Angeles, Calif.

Creears, Tom H., President
Chicago Pump Company
1824 South Hope Street
Los Angeles, Calif.

Cromer, Lyle
Operator North Disposal Plant
Rt. 2, Box 183
Stockton, Calif.

Currie, David H.
300 N. Bradbury
San Gabriel, Calif.

Currie, Frank S.
Consulting Engineer
219 Andreson Building
San Bernardino, Calif.

Dakan, Earl W.
Engr. Industrial Hygiene Service
3093 Life Science Bldg.
Berkeley, Calif.

Daley, A. C.
Operator
1191 North Los Robles Ave.
Pasadena, Calif.

Davids, E. M.
Gladding McBean and Co.
2901 Los Feliz Blvd.
Los Angeles, Calif.

Davidson and Fulmor
Consulting Civil Engineers
3746 Seventh St.
Riverside, Calif.

DeMartini, Frank E.
Asso. Public Health Engineer
c/o U. S. Public Health Service
3rd & Kilgore Sts.
Cincinnati, Ohio

Derby, Ray L.
Asst. Sanitary Engineer
Dept. of Water and Power
Box 240 Arcade Annex
Los Angeles, Calif.

Dommes, Sid F.
244 Fifth Street
Richmond, Calif.

Donaldson, David
Engineer
326½ So. Garfield
Alhambra, Calif.

Duncan, Roland F.
Operator Sewage Disposal Plant
624 Howard Street
Santa Paula, Calif.

Eastman, T. F.
Drainage Design Engineer
701 City Hall
Oakland, Calif.

Egan, J. H.
c/o Crane Company
321 East 3rd Street
Los Angeles, Calif.

Ellinger, Morris
Assistant Engineer
Arrowhead Lake Corp.
Box 338
Lake Arrowhead, Calif.

Eliassen, Rolf
Sanitary Engineer
The Dorr Co. Inc.
811 West 7th St.
Los Angeles, Calif.

Faccinia, Frank
Operator—South Plant Stockton
427 South Harrison St.
Stockton, Calif.

Fairbanks, E. G.
Health and Safety Commission
City of Manteca
Box 66
Manteca, Calif.

Farley, L. C.
Construction Engineer
746 City Hall
Los Angeles, Calif.

Fitch, T. A.
Director Bureau of Standards
City of Los Angeles
826 Yale Street
Los Angeles, Calif.

Foreman, Merle S.
Bacteriologist - Chemist
3093 Life Science Bldg.
Berkeley, Calif.

Foster, Herbert B. Jr.
Asst. Sanitary Engineer
State Dept. Public Health
377 Coventry Road
Berkeley, Calif.

Foster, Wm. Floyd
Engr. of Sewer and Storm
Drain Design
307 W. 1st St.—4th Floor
Los Angeles, Calif.

Fraschina, Keeno
Asst. Supt. and Technician
Richmond Sunset Sewage Treatment
Plant
San Francisco, Calif.

Frick, A. L. Jr.
District Manager
Wallace and Tiernan Co.
2311 East 8th St.
Los Angeles, Calif.

Frickstad, Walter N.
City Engineer
City Hall
Oakland, Calif.

Froehde, F. C.
City Engineer
City Hall
Pomona, Calif.

Gardner, R. T.
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Director Dept. Public Works
Room 260 City Hall
San Francisco, Calif.

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Bureau of Standards L. A.
4608 W. Avenue 41
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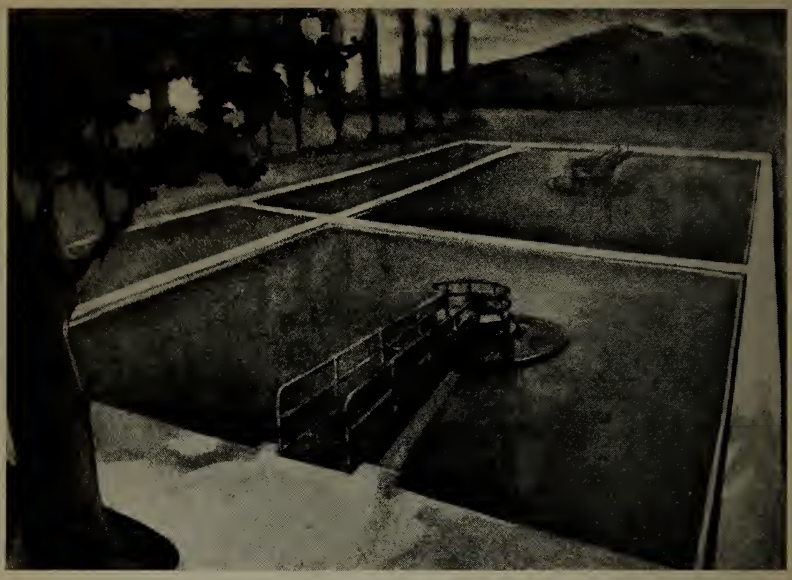
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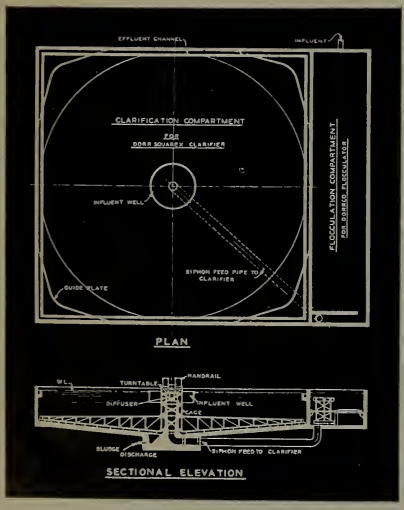
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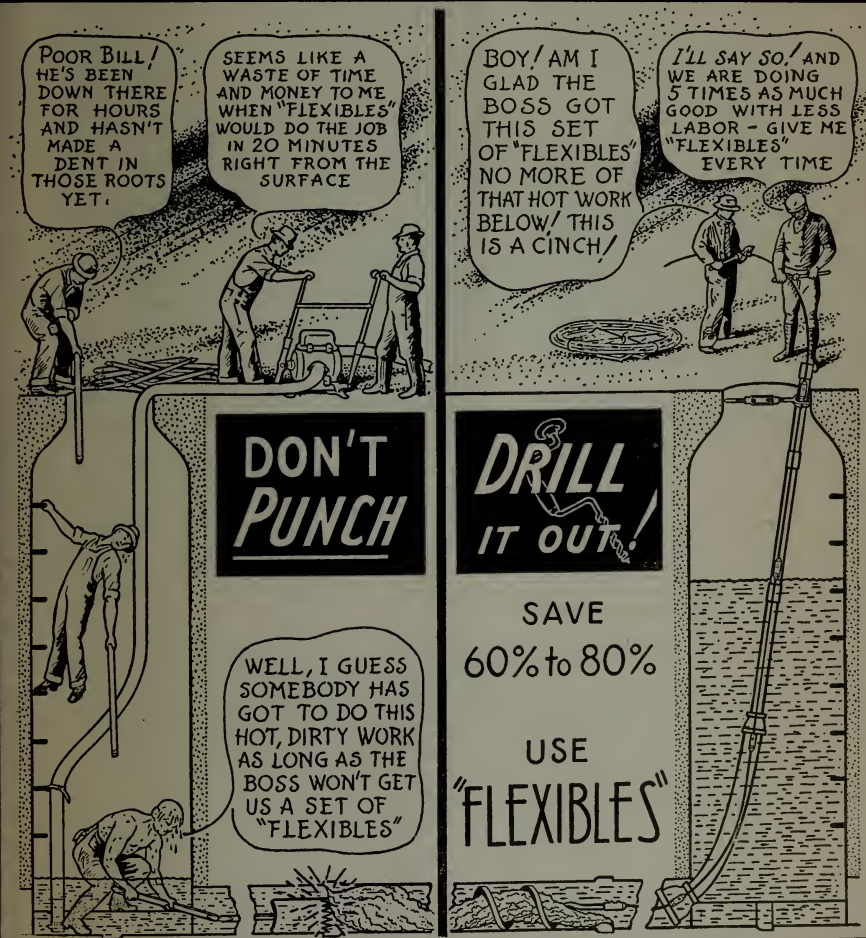
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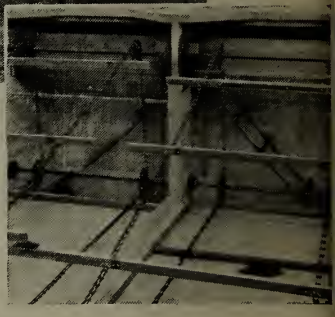
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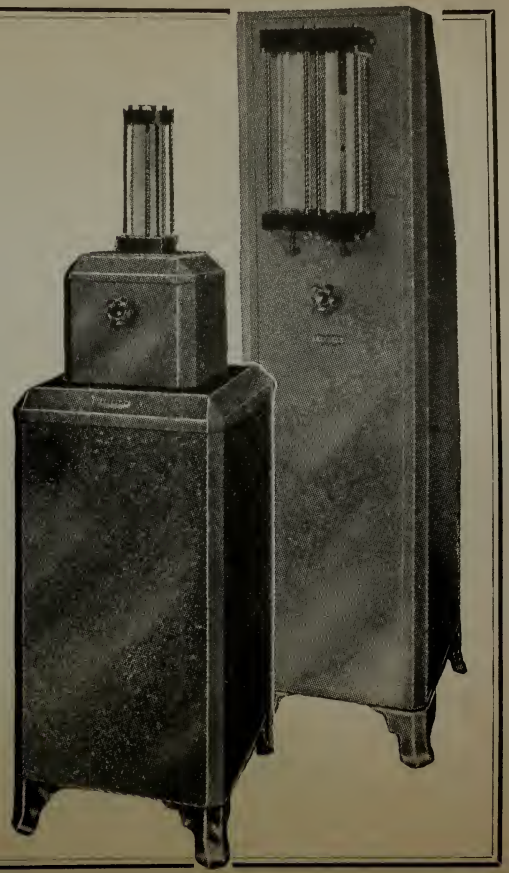
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Let's be specific. "Taffy" is the impurity in Liquid Chlorine that gives you the most trouble. It is the persistent, sticky gum that causes many chlorinator irregularities. And its chief constituent is *hexachloroethane.*

Remove the "taffy" and you've solved one of your operating problems. We have reduced "taffy" to a negligible quantity in the Liquid Chlorine supplied to you. It is only one of the many improvements we have made to insure smooth operation of chlorinators.

We can supply this pure Liquid Chlorine promptly in any desired quantity. It will be a privilege to quote on your requirements.

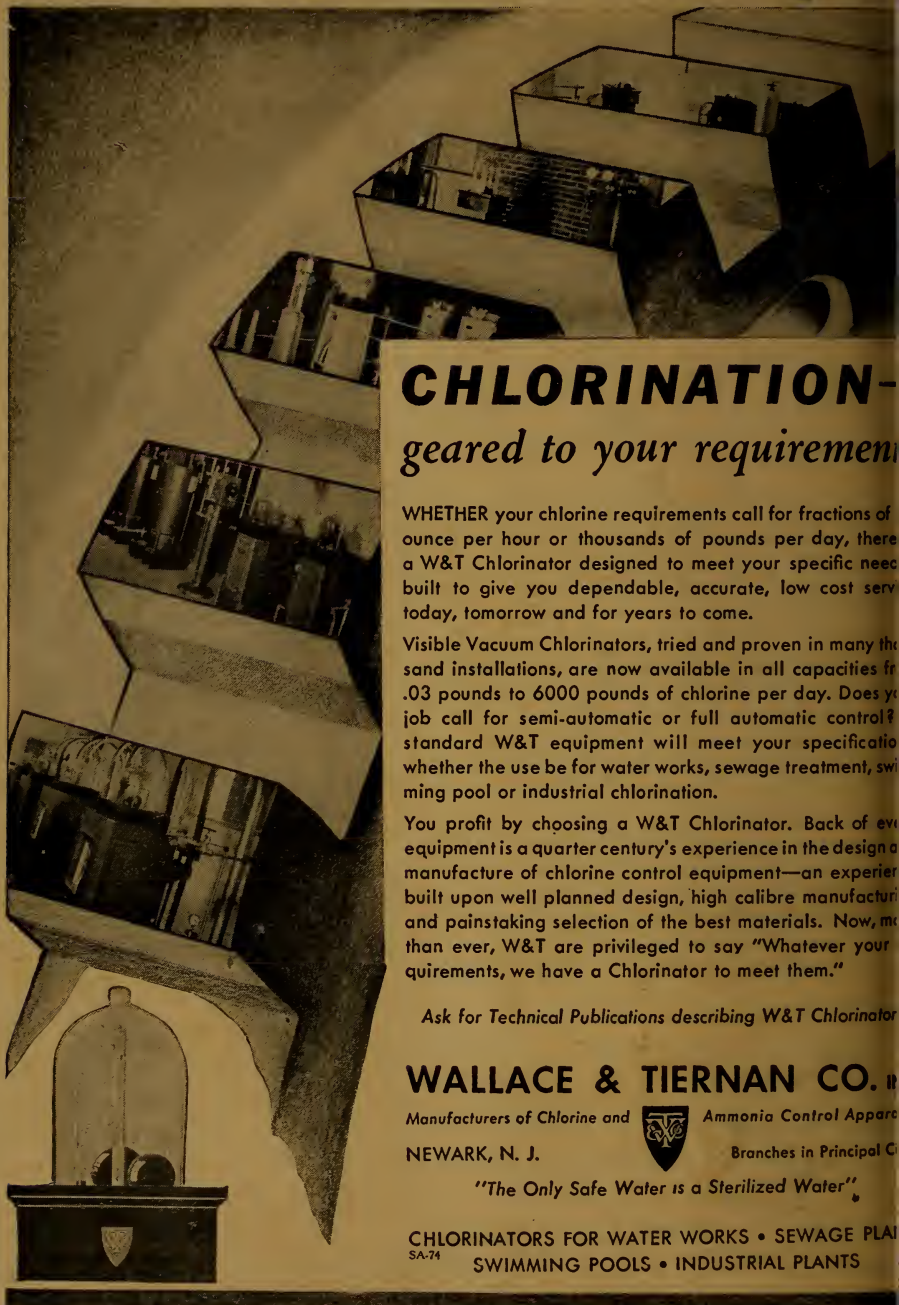
Liquid Chlorine

PENNSYLVANIA SALT MANUFACTURING CO. OF WASHINGTON

Tacoma, Washington

PENNSYLVANIA SALT *Chemicals*

REAL VALUE FOR YOUR CHLORINATION DOLLA



CHLORINATION-

geared to your requiremen

WHETHER your chlorine requirements call for fractions of ounce per hour or thousands of pounds per day, there a W&T Chlorinator designed to meet your specific need built to give you dependable, accurate, low cost servi today, tomorrow and for years to come.

Visible Vacuum Chlorinators, tried and proven in many tho sand installations, are now available in all capacities fr .03 pounds to 6000 pounds of chlorine per day. Does yo job call for semi-automatic or full automatic control? standard W&T equipment will meet your specificatio whether the use be for water works, sewage treatment, swi ming pool or industrial chlorination.

You profit by choosing a W&T Chlorinator. Back of eve equipment is a quarter century's experience in the design a manufacture of chlorine control equipment—an experien built upon well planned design, high calibre manufacturi and painstaking selection of the best materials. Now, mo than ever, W&T are privileged to say "Whatever your quirements, we have a Chlorinator to meet them."

Ask for Technical Publications describing W&T Chlorinator

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"The Only Safe Water is a Sterilized Water"

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